PAPERS OF THE MICHIGAN ACADEMY OF SCIENCE ARTS AND LETTERS

XXXIV (1948)

PART I: BOTANY AND FORESTRY

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MICHIGAN ACADEMY OF SCIENCE ARTS AND LETTERS

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PAPERS OF THE MICHIGAN ACADEMY OF SCIENCE ARTS AND LETTERS

EDITORS
EUGENE S. McCARTNEY
FREDERICK K. SPARROW

VOLUME XXXIV (1948)

PART I: BOTANY AND FORESTRY

"Pusilla res mundus est nisi in illo
quod quaerat omnis mundus habeat."
— SENECA, *Naturales Quaestiones*

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BOTANY

BEACHPOOL DEVELOPMENT AT SEDGE POINT, DOUGLAS LAKE, MICHIGAN *

FRANK C. GATES

INTRODUCTION

BEACHPOOLS are areas of water cut off from main bodies of water in certain ways. The going out of the tide and the going down from heavy storm waves often form temporary pools. A sudden dropping of the water level, caused by the lowering of a lake outlet, may leave permanent beachpools. Beachpools may be built up in bays by the direct onshore action of waves. Such pools are likely to be crescentic, that is, arcs of circles. Alongshore currents, either normal or wind-induced, may start bars in the lee of points projecting out into the lake. Under favorable conditions such bars may come above water, forming spits which may arc around to the land and cut off a pool. This paper is concerned with the observed development of such a beachpool at Douglas Lake, the location of the Biological Station of the University of Michigan, in the extreme northern part of the Lower Peninsula of Michigan.

The lay of the land, the shallowness of the water to the windward, and the kind of bottom at Sedge Point are ideal for the development of beachpools because of the action of the prevailing winds, which are of the alongshore type.

PAST HISTORY

Melting down of the Late Wisconsin glacier left a broad shelf south of the highland running from Stony Point to north of North Fishtail Bay (Fig. 1). In prehistoric times a large beachpool was formed on this shelf. It developed into a bog and persisted as such until severe fires in 1919 burned out the sphagnum ring which held up the water table.

Farther south on this shelf additional beachpools have been developed, as indicated on the map (Fig. 2). Pool 4, cut off previous to the estab-

* Contribution No. 492, Department of Botany, Kansas State College, Manhattan, Kansas.

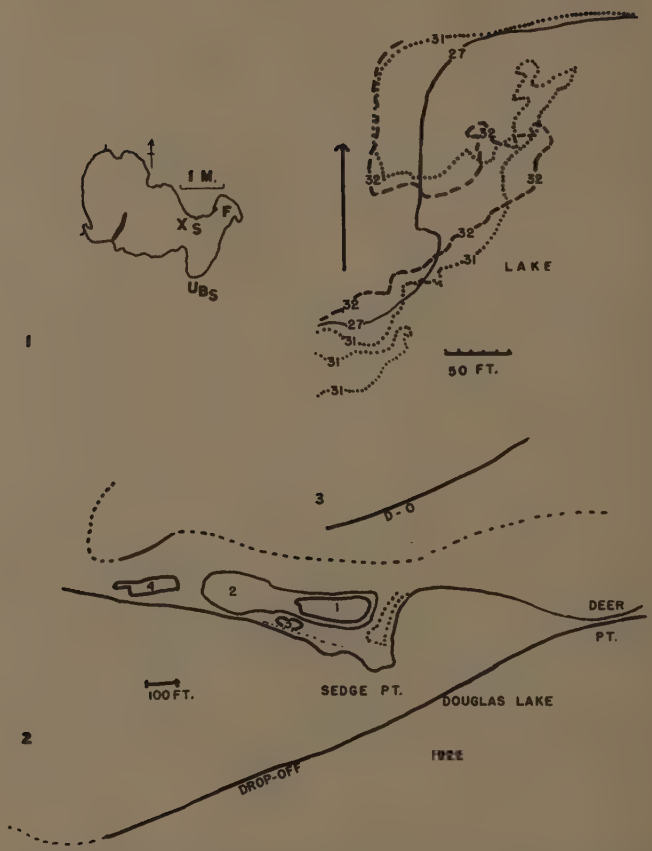

FIG. 1. Douglas Lake, showing the locations of the University of Michigan Biological Station (*UBS*), North Fishtail Bay (*F*), the Sedge Point region (*S*), and Stony Point (*X*). Scale: 1 M. equals one mile

FIG. 2. The Sedge Point area, showing the different pools as they were in 1922. The scale is placed over the shoal from which the sand comes. The abortive pool to the east of Pool 1 is outlined with dots

FIG. 3. The shorelines in 1927, 1931, and 1932

(The numbers along the shorelines in Figures 3–7 are those of the last two digits of the year.)

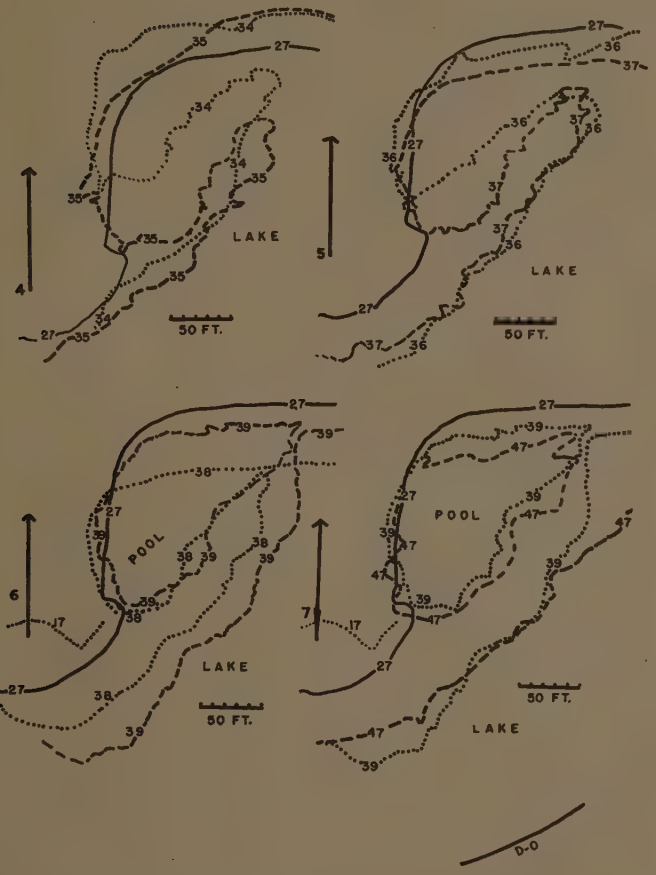

FIG. 4. The shorelines in 1927, 1934, and 1935
FIG. 5. The shorelines in 1927, 1936, and 1937
FIG. 6. The shorelines in 1937, 1938, and 1939 (the year of cutting off of the newest beachpool)
FIG. 7. The shorelines in 1927, 1939, and 1947, together with a small portion of that in 1917

lishment of the Biological Station, through the accretions due to the growth of plants and materials washed and blown into it, has developed into dry land since the present study began in 1911.

Pools 1, 2, and 3 were cut off next as a group before the establishment of the Biological Station. All contained open water at the beginning of the present study. Since that time Pool 3 has been completely filled up by sand washed in by high water. Pool 2 has filled up by the growth of vegetation of a mixed swamp-bog nature, while Pool 1 remains open water, although not so deep as formerly.

CONDITIONS AT THE PRESENT TIME

At the present time an extensive sandy shoal lies to the west of Sedge Point. Its shallowness permits even ordinary storm waves to churn the sandy bottom. Sand thus churned is moved along the bottom eastward. Some thrown up onto the shore dries and is blown into low sand dunes west of the point. By far the larger quantity is worked to the point, where part is thrown ashore by waves, to build the point farther out into the lake. A larger quantity is swirled around the point to form bars in the bay. Succeeding storms may disperse these bars, change their location, or add to them. It seems to make no difference whatever whether any vegetation, submerged or emersed, is growing on or near the bar.

Such has been the history of the Sedge Point region both previous to the establishment of the Biological Station in 1909 and for many years thereafter. Time after time it seemed that a beachpool would be initiated, but the bars were dispersed in the water or worked up onto the shore. Meanwhile the point itself was steadily projecting farther and farther out into Douglas Lake. Sand was added continually to the point during summer storms and pushed up by icework in spring. Rows of willows, mixed with grasses and forbs, starting in damp sand, or sometimes in clumps of Typha, or half-buried *Scirpus americanus*, anchored the sand. This prevented the westerly winds from blowing much sand into the water immediately east of the point, where it would have formed land in a place which otherwise might have become a beachpool.

Sedge Point was thus built out into the lake about 160 feet from 1911 to 1929. During the early part of this time a new pool was forming to the east of Pool 1. Fires in 1919 cleared the vegetation from most of the point and permitted enough sand to blow into the incipient pool to bring

it above the general water-table level. It exists now as a depression east of Pool 1 and can easily be recognized from the dune area surrounding it by the more hydric nature of its vegetation.

In 1926 the level of Douglas Lake was exceptionally low, and much sand was brought onto and past the point, more than could be dispersed in the following years. In 1931, another exceptionally low-water year, the bar east of the point was above water much of the summer. Many seedlings invaded this bar and, although moved about by the icework the next spring, were not all washed away. Sand caught by these plants built up the spit. No sand remained to add to the bottom of the bay beyond. Alongshore movement of the sand added new bars that extended out into the bay. The sand spit thus initiated lengthened year after year and finally cut off a section of the bay as a beachpool.

Growth of the spit was erratic. Several westerly storm winds moved in quantities of sand, which swirled around the spit and added to its tip. Occasional southeast storms would finger out the unconsolidated sand at the tip of the spit. Higher water from 1934 through 1937, resulting from a dam at the outlet of Douglas Lake, did not destroy the spit, although it did work changes in the shoreline. Consolidation by vegetation and addition of wind-blown sand maintained the backbone of the spit, and it was added to each year. Such additions were on the lake side and became consolidated by vegetation, so that the bottom of the pool to be was not built up.

After the dam was blown out, additions to the spit became more rapid. In 1939 the gap between the spit and the shore of the bay was closed, and gave rise to a new beachpool 90 by 190 feet in extent.

Subsequently this spit has grown in width and consolidation to become a permanent feature of the area. New fingerlike bars are forming, dispersing, re-forming in and out of vegetation (mostly sparse submerged potamogetons), while the point itself is moving slowly out into the lake toward the drop-off. The conditions perhaps favor the building up of the backbone of the point rather than furnish sufficient sand to build a new spit, whose development might cut off another part of Sedge Bay as an additional beachpool.

Maps made from surveys by ecology classes under the supervision of the author show the shorelines in Sedge Bay in the years indicated. The shoreline in 1927, which was about at the end of the "preparation" pe-

riod, is indicated on each map for comparison. Outlines for two additional years are shown in each figure. Although the surveying was done at about the same time each summer, different heights of water level make for variations in the exact location of the shoreline; even so the continuous building up of the spit is obvious (Figs. 3–7).

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ADDITIONS TO THE FLORA OF KALAMAZOO COUNTY, MICHIGAN

CLARENCE R. HANES

SINCE the publication of the *Flora of Kalamazoo County, Michigan*,[1] in 1947 several additions can be made to the plants listed in that treatment. They are, with one exception, collections of Mrs. Florence N. Hanes and the writer or specimens at present deposited in the Kalamazoo Museum. The two groups will be listed and discussed separately.

PART I

List of Species

EQUISETUM ARVENSE L. var. BOREALE (Bong.) Rupr. — In the *Flora of Kalamazoo County, Michigan,* only *E. arvense* is treated, and none of the described varieties or forms of that species are noted. A statement is there made that we have specimens approaching forma *pseudosylvaticum* (Milde) Luerss. Recent collections show that we may also have the so-called variety *boreale*. However, in our studies we come across confusing characters, which raise the question whether the variations observed in this species are not ecological. Typical *E. arvense* is considered to have the sheaths of the primary branches 4-toothed, whereas those of variety *boreale* are 3-toothed.

Our specimens that were collected in swamps and near springs always had branches with 3-toothed sheaths; those from upland fields and along railroads had 4-toothed sheaths on the primary branches. The confusing characters apply to plants growing on the higher ground which borders swampy areas. Here about half of the specimens collected have branches with 4-toothed sheaths and half with 3-toothed sheaths. Often these swamp-bordering plants with 4-toothed sheaths have on the primary branches of the same individual a few with 3-toothed sheaths, and the one with 3-toothed sheaths could boast of a

[1] Hanes, Clarence R., and Hanes, Florence N., *Flora of Kalamazoo County, Michigan: Vascular Plants.* Privately printed. Schoolcraft, Michigan, 1947.

scattering of branches with 4-toothed sheaths. The observations noted above have been found true in collections made on swamp borders east of Sugarloaf Lake, in Section 31, Schoolcraft Township, and at Cold Springs, Alamo Township.

The swamp plants had, with scarcely an exception, simple branches; those from upland fields and railroads had compound branches; and those on swamp borders were mainly simple.

ECHINOCHLOA PUNGENS (Poir.) Rydb. var. OCCIDENTALIS (Wieg.) Fern. and Grisc., no. 4611. This is another native variety of *Echinochloa*. It has been found in the "Island" and Krum ponds when they were nearly dry. The determination was confirmed by Dr. F. J. Hermann, of the Bureau of Plant Industry, Washington, D.C.

CAREX FOENEA Willd. — August 8, 1947, F. W. Rapp, no. 6577. Sandy wooded hill near marsh east of Goose Lake. Previous to this collection on the south border of Kalamazoo County the most southerly report for this sedge in Michigan was in Arenac County north of Saginaw Bay.[2] Determination was made by Dr. F. J. Hermann.

IRIS PSEUDACORUS L. — June 19, 1947, no. 3047. This species grows in a creek south of the Kalamazoo River in the easternmost part of Section 25, Ross Township, and also north of the river along that portion of Sevenmile Creek which is in Section 24 of Ross Township. These stations were shown to us by H. R. Becker. It is the European species of *Iris*, often planted for ornament and sometimes found as an escape.

CARYA OVALIS (Wang.) Sarg. var. OBOVALIS Sarg. f. ACUTA Sarg. — October 8, 1947, no. 2147. Along the roadside one-half mile south of Austin Lake. This form, having the obovoid nut with a stipitate base, is given to show that it grows in Kalamazoo County.

OSTRYA VIRGINIANA (Mill.) K. Koch. f. GLANDULOSA (Spach) Macbr. — August 3, 1946, no. 466. "This form has the branchlets, petioles, peduncles, and often the midrib and veins of the lower surface of the leaves covered, more or less, with short, erect, reddish glandular hairs." It was collected in Harter's wood five miles southwest of Schoolcraft.

CHENOPODIUM BUSHIANUM Aellen. — August 26, 1946, no. 4624. *C. Bushianum* has been found in several yards in the village of Schoolcraft.

ATRIPLEX PATULA L. var. LITTORALIS (L.) Gray. — October 14, 1946, no.

[2] Hermann, F. J., "The Genus Carex in Michigan," *Am. Midland Nat.*, 25: 28–29. 1941.

4613. It was discovered on a vacant lot in the city of Kalamazoo. Its identity has been confirmed by Dr. S. F. Blake, of the Bureau of Plant Industry, Washington, D.C.

RUBUS ASSOCIUS Hanes. (Bailey, *Gentes Herbarum,* Addendum I, 7: 330–332. 1947.) This is a beautiful member of the blackberry clan. Its flowers are more profuse than those of any other species of this genus found in Kalamazoo County. It is a new discovery, so named because near by are several plants rare in the county and the state. These are *Eleocharis melanocarpa, Polygala cruciata,* and *Solidago graminifolia* var. *remota.*

Patches of *R. associus* grow on the swamp border fifteen rods south of the southeastern portion of West Lake. In habit the canes may be nearly erect or almost reclining, but even the reclining canes are extremely shy of rooting at the tips.

PART II

The specimens on deposit in the Kalamazoo Museum are the collections of Mr. A. C. Roberts, who made them in the period from 1870 to 1905. The territory of the county in which Mr. Roberts worked was mostly within a few miles of the city of Kalamazoo on the east, south, and west, and on the north to the county line.

The plants are well mounted and well preserved. The various phases of a single species are often depicted by two different forms on the same sheet or by specimens on different sheets. With factory and residence development of the city many of the habitats of Mr. Roberts' plants have been destroyed. His collection, however, preserves a record of the character of the flora in and around Kalamazoo during the latter part of the nineteenth century.

When the *Flora of Kalamazoo County, Michigan,* was published we did not know of any authentic specimens of the first four species given in the following list; for each of the last four we knew of only one station.

LIST OF SPECIES

HABENARIA HOOKERI Torr. — Cooper Township. This collection was made May 30, 1879. *H. Hookeri* resembles *H. orbiculata,* but its flowering season is about a month earlier. The specimen has the scape free of bracts.

SPIRANTHES GRACILIS (Bigel.) Beck. — On the Michigan Central Railroad

right of way, two and one-half miles southwest of Kalamazoo, August 11, 1902. There are two typical specimens of this orchid, rare at least in our county. They were found in nearly the same place in which Frank H. Tuthill made collections in the 1870's. Tuthill's record is given in the *Botanical Gazette*.[3]

ADLUMIA FUNGOSA (Ait.) Greene. — Southwest of Kalamazoo, near Winslow's. No date is given for the specimen, which Mr. Roberts has labeled under its former name, *Adlumia cirrhosa* Raf.

LYSIMACHIA TERRESTRIS (L.) BSP. — Southeast of Kalamazoo beyond Botsford's mill by the Michigan Central Railroad, June 14, 1900. Botsford's mill is on the present site of the Michigan Paper Company's mills. Another specimen is labeled "east of the river near blast furnaces."

HABENARIA LEUCOPHAEA (Nutt.) Gray. — East of Kalamazoo, July 4, 1885. Mr. Roberts says of it: "The only specimen I ever saw."

ARETHUSA BULBOSA L. — Four miles east of Kalamazoo, May 28, 1879; June 17, 1880. Mr. Roberts has a note stating that it is no longer found there.

ROSA SETIGERA Michx. — One and one-half miles south of Kalamazoo by Portage Street and Lake Shore Michigan Southern Railway, June 27, 1899. This rose must formerly have been more abundant than it is at present since Kalamazoo pioneers speak of it in their writings.

PYROLA SECUNDA L. — Three and one-half miles southwest of Kalamazoo, June 25, 1899. There are two typical specimens of this plant rare in southern Michigan.

SCHOOLCRAFT, MICHIGAN

[3] Tuthill, Frank H., "Some Notes on the Flora near Kalamazoo, Michigan," *Bot. Gaz.*, 1 (4) : 13. 1876.

TWO MEMBERS OF THE ACRASIEAE ISOLATED IN MILWAUKEE COUNTY, WISCONSIN

EUGENE D. KITZKE

INTRODUCTION

RECENT studies have contributed much new information about the curious group of organisms belonging to the Acrasieae, an order of the Myxomycetes. From these studies it is becoming obvious that they are of far more frequent occurrence and are more widely distributed than originally supposed. The fact that they are little known can probably be attributed more to the minuteness of their vegetative structure and to the evanescence of their fruiting bodies than to their actual scarcity. The Acrasieae, forming as they do a pseudoplasmodium composed of individual myxamoebae, are distinguished in this feature from other Myxomycetes and are separated in a special order.

MATERIALS AND METHODS

In thirty-three attempts to isolate members of the Acrasieae four have been successful. It was determined that three of the fungi recovered belonged to the genus *Dictyostelium* and one to *Polysphondylium*.

Source of Materials

Table I lists the sources of the isolates. The sources that proved productive seem to show no correlation in the type of substratum or of habitat.

In Table II a complete listing of the thirty-three sites from which isolations were attempted reveals the distribution of the fungi to be widespread. Considering that four isolates were yielded from thirty-three attempts, one can conclude that the members of this group are fairly common in distribution.

Method of Isolation

Material collected from the field was finely macerated and suspended in sterile distilled water. The dilute suspension was streaked upon the

TABLE I

SOURCES OF SAMPLES YIELDING ACRASIEAE

Plate no.	*Isolate*	*Material*
1	Dictyostelium purpureum	Soil and leaf mold
22	Dictyostelium purpureum	Soil and manure
29	Polysphondylium violaceum	Soil and pine needles
30	Dictyostelium purpureum	Soil and corn roots

TABLE II

SITES OF SAMPLES TESTED FOR THE PRESENCE OF ACRASIEAE

(All sites not otherwise designated are in Milwaukee)

SITE	MATERIAL
2100 South 32d Street	Oak leaves and soil
Whitnall Park	Oak and elm leaves and soil
Pulaski Park	Oak and elm leaves and soil
1715 South 11th Street	Oak leaves and soil
Pulaski High School	Oak leaves and dry grass
Forest Home Cemetery	Elm and oak leaves and soil
2810 North Pierce Street	Decomposing grass
Pulaski Park	Elm and maple leaves and soil
Pulaski Park	Hay and dung
Forest Home refuse center	Dry leaves and soil
Marquette University campus	Oak leaves
Arlington Cemetery, Milwaukee Co.	Elm leaves and grass
Marquette University greeenhouse	Soil
Brown Deer riding stable, South Milwaukee	Horse dung
Marquette University campus	Pigeon dung
2406 South 19th Street	Soil and grass
Marquette University greenhouse	Soil
Sacred Heart greenhouse	Decomposing leaf and soil
Sacred Heart garden	Soil
Jackson Park	Rushes, soil, and leaves
Mitchell's Wood, West Allis	Apple orchard soil
Pulaski High School	Fertilizer and soil
20th Street Bridge	Soil, grass, and creek water
St. Barbara's	Palm leaves
Kosciuszko Park	Dung
Kosciuszko Park Lagoon	Soil
Humboldt Park, town of Lake	Soil and leaves
Sheridan Park, Cudahy	Soil and leaves
Sheridan Park, Cudahy	Pine needles and soil
Cudahy, cornfield	Corn roots and soil
South Shore Park, town of Lake	Oak leaves and soil
Jacobus Park, Wauwautosa	Soil and leaves
Washington Park	Rabbit dung, soil, and leaves

surface of mannite agar in petri dishes. These were incubated for two weeks at 16° to 18° C. and examined after that time for evidences of the fungi. If any were present, direct transfers were made to pure culture.

OBSERVATIONS

Dictyostelium purpureum Olive

The organism as grown by the writer on cultures of *Escherichia coli* and hay-infusion agar presented vigorous luxuriant growth of sorocarps ranging from 3 to 10 mm. tall. The sori and stalks were dark purple, the former sometimes being almost black. At early stages the sori were translucent at the periphery owing to the presence of a watery substance, undoubtedly the mucus described by Olive (1902). Plate I, Figure 1, shows this mucus.

The migrating pseudoplasmodia developed well in the media, becoming in some instances 3 to 4 mm. long. Plate II shows a pseudoplasmodium at a stage in which the sorophore initial is already visible within the mass. At the upper right radiations from another group of myxamoebae can be seen.

The sorophore under high magnification shows typical cellulose-walled myxamoebae which have gone into the construction of the stalk (Pl. I, Fig. 2).

The spores (Pl. I, Fig. 3) were 7.3–5.5 μ long by 3.–3.5 μ wide and ovoid, as stated by Olive. There was little variation in size. The further fate of these spores was not followed.

Polysphondylium violaceum Brefeld

Since this is the only member of *Polysphondylium* described as having the characteristic purplish to dark-violet hues, it was relatively easy to identify.

The organism grew luxuriantly on *Escherichia coli,* developing numerous normal fruiting structures with typical branches occasionally giving rise to small single unbranched sorophores with one sorus at the tip. On the red-pigmented bacterium, *Serratia marcescens,* the growth was less luxuriant, and all the resulting fructifications had marked abnormalities. The branches were incomplete and the sorophores twisted, and some pseudoplasmodia did not develop to the sorophore stage.

The sorophores at times attained lengths ranging from 2 to 14 mm. The number of nodes ranged from 3 to 7. Lateral branches tapering

toward the extremities bore dark-violet sori. Plate III shows a highly magnified view of the main stalk with a branch at right angles to it.

The spores (Pl. I, Fig. 4) varied somewhat in size, being 8.4–6 μ long and 2.8–4.5 μ wide. They were ovoid to elongated-ovoid, as described by Olive.

Typical fructifications can be seen in Plate IV, although the difficulty of photographing the upright delicate structures prevented the obtaining of any really good views. On this plate one can also see a typical radiation of aggregating myxamoebae on the agar in the background.

SUMMARY

Field investigations of Milwaukee County, Wisconsin, are reported, with four successful isolations of members of the Acrasieae. Both *Dictyostelium purpureum* and *Polysphondylium violaceum* were cultured in the laboratories for study and photographing. The former was isolated from three different localities; the latter, from only one.

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LITERATURE

Bonner, J. T., and Eldridge, Donald. 1945. A Note on the Morphogenetic Movement in the Slime Mold, *Dictyostelium discoideum*. Growth, 9: 287–298.

Greene, E. C. 1932. Wisconsin Myxomycetes. Trans. Wis. Acad., 27: 141–182.

Harper, R. A. 1926. Morphogenesis in Dictyostelium. Bull. Torrey Bot. Club, 53 (5): 229–268.

—— 1929. Morphogenesis in Polysphondylium. *Ibid.*, 56 (5): 227–258.

Howard, Frank. 1931. Laboratory Cultivation of Myxomycete Plasmodia. Am. Journ. Bot., 18 (8): 624–628.

Krzemieniewski, Helena S. 1927. Z Mikroflory gleby w Polace. Acta Soc. Bot. Poloniae, 4: 141–144.

Olive, E. W. 1902. Monograph of the Acrasieae. Proc. Boston Soc. Nat. Hist., 30: 451–513.

Raper, Kenneth B., and Thom, Charles. 1932. Distribution of Dictyostelium and Other Slime Molds in Soil. Journ. Wash. Acad. Sci., 22 (4): 93–96.

Raper, Kenneth B. 1935. *Dictyostelium discoideum*, a New Species of Slime Mold from Decaying Forest Leaves. Journ. Agric. Res., 50: 135–147.

—— 1937. Growth and Development of *Dictyostelium discoideum* with Different Bacterial Associates. *Ibid.*, 55: 289–316.

—— 1939. Influence of Culture Conditions upon Growth and Development of *Dictyostelium discoideum*. *Ibid.*, 58: 157–198.

RAPER, KENNETH B. 1940. Communal Nature of the Fruiting Process in the Acrasieae. Am. Journ. Bot., 27:436–448.

—— 1940. Pseudoplasmodium Formation and Organization in *Dictyostelium discoideum*. Journ. Elisha Mitchell Sci. Soc., 56(20): 241–282.

—— 1941. *Dictyostelium minutum*, a New Species of Slime Mold from Decaying Forest Leaves. Mycologia, 33(6): 633–649.

SINGH, B. N. 1946. Soil Acrasieae and Their Bacterial Food Supply. Nature, 157: 133–134.

THOM, C., AND RAPER, KENNETH B. 1930. Myxamoebae in Soil and Decomposing Crop Residues. Journ. Wash. Acad. Sci., 20(15): 362–370.

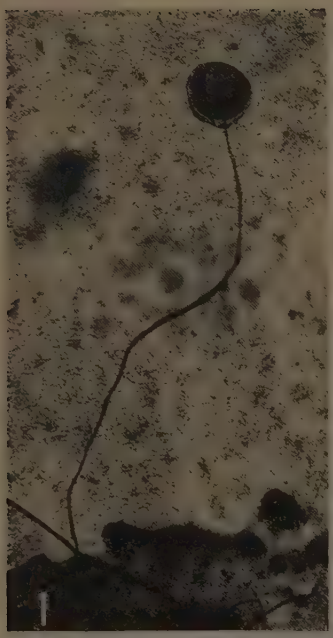
EXPLANATION OF PLATE I

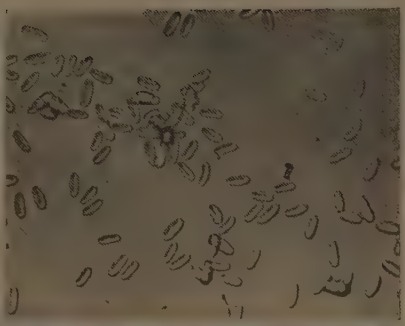
FIG. 1. Sorocarp of *Dictyostelium purpureum*. × 40. Notice the periphery of mucus around the sorus. It evaporates as the structure becomes older

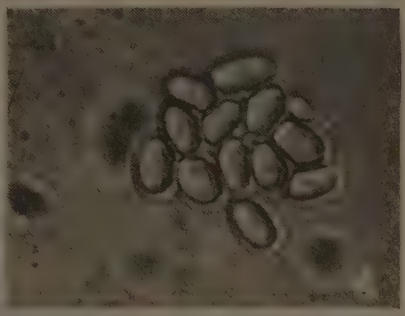
FIG. 2. Sorophore section of *Dictyostelium purpureum*. × 670. Cellulose walls can be seen on the individual cells. The heavy side walls of the sorophore are formed by layers of mucus deposited by migrating myxamoebae

FIG. 3. Spores of *Dictyostelium purpureum*. × 670

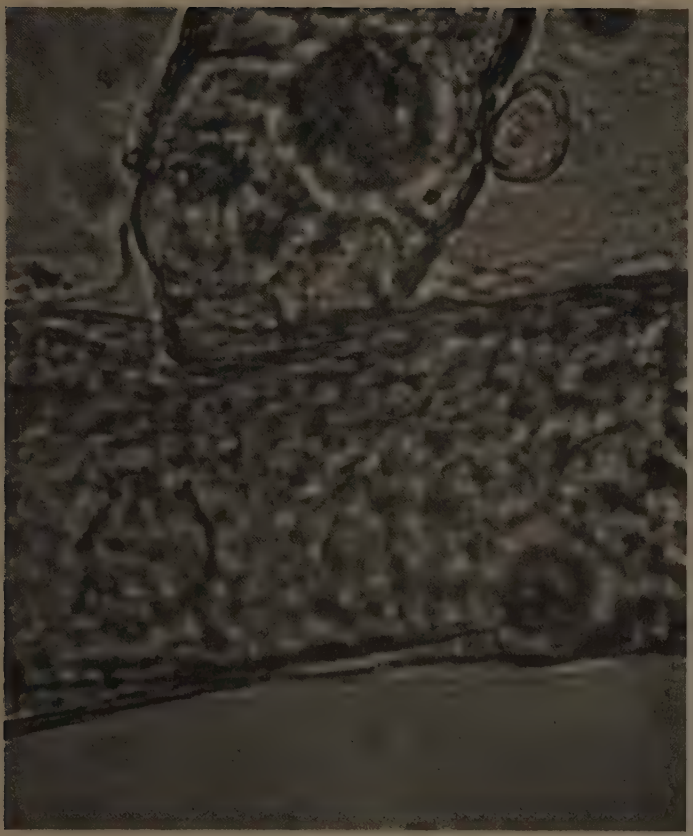
FIG. 4. Spores of *Polysphondylium violaceum*. × 1200







Pseudoplasmodium of *Dictyostelium purpureum*. × 130. The pointed tip is the apical point. The slimy trail left in the agar can be seen at the end of the pseudoplasmodium opposite the apical tip. The upper right-hand portion of the photograph shows radiations of a newly formed aggregation of myxamoebae



Main stalk and branch axis of sorophore of *Polysphondylium violaceum*. × 1535

A sorocarp of *Polysphondylium violaceum*, showing lateral branching with the terminal sorus uppermost. × 35. Radiations of aggregating myxamoebae can be seen in background

SUGAR-BEET CROWNS AS A SUBSTRATUM FOR FERMENTATION PROCESSES *

MILO N. MICKELSON, ANDY GREGOR, AND DEXTER ROGERS

INTRODUCTION

DURING the course of investigations to gather information which would lead to more profitable utilization of sugar-beet residues attention was called to the fact that the top portion of the beet in the Michigan sugar-beet growing area is largely wasted. This portion, referred to as the "crown" by the industry, has only limited value as a livestock food. The amount of this material in the Michigan area is appreciable. It was estimated for 1945 to represent about 40,000 tons of sugar.

Agricultural residues such as straw, cornstalks, and corncobs and wood residues such as sulphite liquor and sawdust hydrolysates have all been given consideration as sources of carbohydrate material for fermentation. With these materials the cost of collection and preparation for fermentation has been a major obstacle to their profitable use. This should not be true of sugar-beet crowns. They could be collected along with the portion of the beet processed for sugar and removed at the plant to be dried or prepared in the form of a syrup. The carbohydrate in the crown is already in fermentable form, that is, no conversion is necessary. It is estimated that carbohydrate from sugar-beet crowns could be made available for about two cents per pound. This figure places it in the price range which is likely to be attractive to those engaged in procuring carbohydrate for fermentation plants.

The shortage of cheap carbohydrate is a problem that has caused concern among those engaged in fermentation industries. During and since

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the war blackstrap molasses and high invert cane syrup have not been generally available. It is likely that in the future raw materials will not be as available or as cheap as they were prior to the war. Furthermore, some who are enthusiastic about the ion-exchange process for refining sugar cane and sugar-beet extracts predict that by-products of these processes, namely, blackstrap and sugar-beet molasses, will not be as procurable as they have been in the past. In view of the anticipated shortage of carbohydrates for the fermentation industries any new source of this raw material would be of inestimable value.

It was felt that the sugar-beet crowns might provide an excellent source of carbohydrate as raw material for the production of chemicals by fermentation. With the end in view of investigating such a possibility a preparation of dried ground sugar-beet crowns was made which contained about 45 per cent sucrose. This material was employed as a substrate in the 2,3-butylene glycol fermentation by *Aerobacter aerogenes*, ethyl alcohol fermentation by yeast, lactic acid fermentation by a strain of *Lactobacillus*, and butyl alcohol-acetone fermentation by a saccharolytic and by an amylolytic type of butyl alcohol-acetone bacteria.

EXPERIMENTAL

The crowns were received in the laboratory as soon as possible after harvesting. They were washed to remove the adhering soil and sliced in pieces one eighth of an inch thick with a manually operated laboratory slicer. The pieces of tissue were then placed at 37° C. to dry. When brittle, they were finely comminuted in a small burr mill. The resulting product assayed 45–47 per cent sucrose, and less than 5 per cent moisture, and was hygroscopic. Previous to hydrolysis there was no reducing sugar present. This material was used alone and in combination with beet molasses as a source of carbohydrate in the various fermentations investigated. In some of the studies on 2,3-butylene glycol fermentation diffusion juice was used which had been preserved by the addition of toluene and stored at 5° C.

THE PRODUCTION OF 2,3-BUTYLENE GLYCOL BY AEROBACTER AEROGENES

The major portion of this work was carried out during the summer of 1942 and the winter of 1942–43. Concurrently there was an unusual interest in 2,3-butylene glycol as an intermediate for the production of butadiene in connection with the synthetic rubber program. The initial studies employed diffusion juice and beet molasses. During 1944–45,

when beet crowns became available, several experiments were run in order to compare this material with beet molasses and diffusion juice as a substratum.

From a group of six strains of *A. aerogenes* one was selected which, under the conditions of the experiment, utilized the sugar most rapidly and gave the highest yields of glycol. The inoculum was developed by transferring the organisms from a stock culture to a broth medium of the following composition: 10 per cent sucrose, 0.3 per cent $(NH_4)_2SO_4$, 0.1 per cent K_2HPO_4, an excess of $CaCO_3$ and pH 6.8. After two transfers in this broth medium the organism grew luxuriantly and was ready for the inoculation of the test media.

The reactions were carried out in 2-liter Florence flasks. Thirteen hundred ml. of the medium to be fermented was placed in each flask and after sterilization was inoculated with 2 per cent of a 24-hour broth culture, as just described. An alundum sparger was submerged in the medium, and washed filtered air was introduced at the desired rate.

When diffusion juice was used, because of frothing of the medium, the reaction was adjusted to pH 6.5 and the medium brought to a temperature of 65° C. in a water bath, before carrying out the sterilization in the autoclave. Colloidal material was precipitated during the preheating. The dried comminuted sugar-beet crowns were sterilized with a minimum amount of water and diluted to volume with sterile broth containing the usual salts. Analyses were made at the beginning and end of each experiment for the sugar content of the medium by the method of Shaffer and Somogyi (1933). The 2,3-butylene glycol was determined according to the procedure used by Mickelson and Werkman (1938). Representative data are presented in Tables I, II, and III.

Table I gives the results of two experiments in which sugar-beet diffusion juice was used as the carbohydrate source. No nutritive supplements were added, but $CaCO_3$ equal to 1 per cent of the sugar was added to control the acidity. Sterile lard oil, 1 ml. per liter of medium, was used to inhibit frothing. Aeration was begun 12 hours after inoculation.

Complete utilization of the 7 per cent sugar was achieved in 48–72 hours. The yields of 2,3-butylene glycol, expressed in millimoles per 100 millimoles of fermented sugar, represent the percentage theoretical yield. The yields may be slightly high, since no correction was applied for acetylmethylcarbinol in the glycol distillate. Qualitative tests indicated only a small amount to be present.

Since diffusion juice is quite dilute, one can incorporate some concen-

trated sugar syrup such as beet molasses to increase the carbohydrate ratios. Combinations of beet molasses and beet diffusion juice were prepared in the following manner: 193 grams of beet molasses was added to 1000 ml. of diffusion juice; the pH was adjusted to 6.5; and the mixture was preheated, then sterilized in the autoclave. The results are presented in Table II. In experiments 1, 2, 3, and 4 very good fermentations ensued. The yields of 2,3-butylene glycol were unusually good in experiments 3 and 4. The media in experiments 5 and 6 were supplemented with urea and KH_2PO_4, as indicated in the table. The fermentation in experiment 5 was slower than that in the first three, but the yield of glycol was good. In experiment 6, when the aeration rate was increased, fermentation was rapid but the yield of glycol was lower.

TABLE I

AEROBIC FERMENTATION OF SUGAR-BEET DIFFUSION JUICE BY A. AEROGENES
(Aerated with 75 ml. air per liter per minute.)

Exper.	Time hrs.	Sugar conc. gm./100 ml.	Pct. sugar consumed	Yield of 2,3-butylene glycol	
				mM. per 100 mM. fermented sugar	Pct. yield on weight basis
1	72	6.9	97	87.00	43.5
2	72	7.0	96	89.00	44.5

TABLE II

AEROBIC FERMENTATION OF MIXTURES OF SUGAR-BEET DIFFUSION JUICE AND MOLASSES BY A. AEROGENES

Exper.	Time hrs.	Aeration ml. air/ L./min.	Grams sugar/ 100 ml.	Pct. sugar fermented	Yield of 2,3-butylene glycol	
					mM. per 100 mM. fermented sugar	Pct. yield on weight basis
1	96	75	12.00	94	88.0	44.0
2	96	75	12.00	80	88.5	44.2
3	100	75	12.00	80	97.5	48.7
4	100	75	12.00	75	93.2	46.7
5*	168	75	12.00	93	88.5	44.2
6†	88	375	12.25	90	78.5	39.2

* 5 — 0.3 per cent urea, 0.2 per cent KH_2PO_4 added.
† 6 — 0.15 per cent urea, 0.1 per cent KH_2PO_4 added.

In 1944 and 1945 experiments similar to those described were pursued in which the dried beet-crown material was used as a source of carbohydrate and the medium was augmented with 0.15 per cent urea.

When beet crowns alone were used as substrate 50 grams of the dried material was sterilized with a small amount of water, and water and salts added after removal from the autoclave, to make a volume of 350 ml. The medium containing beet crowns and beet molasses was prepared by adding, to 65 grams of the dried beet crown and 193 grams of beet molasses, tap water to a final volume of 1400 ml. The mixture was adjusted to pH 6.5 and preheated before sterilization, as described for diffusion juice. The final sugar concentration was equal to that of diffusion juice.

Beet crowns alone or in combination with beet molasses fermented as readily as did the diffusion juice-molasses combination. Table III gives the results of these experiments. In no instance was the yield of 2,3-butylene glycol as high as that in the previous experiments. This may be due to the adverse effect of the inorganic ions in the beet crowns. It has been shown by Ward, Pettijohn, and Coghill (1945) that the ionic composition of the medium does affect the yields of 2,3-butylene glycol that can be obtained with *A. aerogenes*.

TABLE III

AEROBIC FERMENTATION OF SUGAR-BEET CROWNS, AND SUGAR-BEET CROWNS WITH BEET MOLASSES ADDED, BY A. AEROGENES

(Aerated with 75 ml. air per liter per minute.)

Exper.	Time hrs.	Sugar conc. gm./100 ml.	Pct. sugar fermented	Yield of 2,3-butylene glycol	
				mM. per 100 mM. fermented sugar	Pct. yield on weight basis
1	48	4.7	95	62.0	31.0
2	40	4.0	100	67.8	33.9
3	96	8.4*	100	61.7	30.9

* 26 per cent of sugar from beet crown; 74 per cent of sugar from beet molasses.

Results

1. Sugar-beet diffusion juice was readily fermeted by *A. aerogenes* and gave good yields of 2,3-butylene glycol.

2. Diffusion juice augmented with beet molasses to a sugar concentration of 12 per cent gave yields of the glycol equal to those obtained from diffusion juice.

3. When the rate of aeration exceeded 75 ml. per liter of medium per minute, sugar consumption was more rapid, but the yields of glycol were lower.

4. Sugar-beet crowns and combinations of sugar-beet crowns and beet molasses were readily fermentable, but gave lower yields of the glycol than the other media studied.

ALCOHOLIC FERMENTATION OF SUGAR-BEET CROWNS BY YEAST

Some of these experiments were carried out in aqueous extracts of the ground beet crown and some in media prepared with the whole crown. The fermentation procedure was that described by Stark, Adams, Scalf, and Kolachov (1943). The yeast used was a distiller's strain of yeast designated *Saccharomyces cerevisiae* (D. C. L.).

TABLE IV

ALCOHOLIC FERMENTATION OF SUGAR-BEET CROWNS BY S. CEREVISIAE

Substrate	Time hrs.	Sugar conc. gm./100 ml.	Pct. sugar consumed	Percentage yield of alcohol on sugar fermented
Beet-crown extract	68	4.44	100.0	77.0
	68*	4.44	100.0	84.0
	68†	4.44	100.0	85.6
Whole beet crown	96	6.43	95.5	101.0
	93	6.43	92.3	103.0
	96*	6.43	96.0	96.0
	93*	6.43	92.2	96.0
	96†	6.43	95.5	96.0
	93†	6.43	92.5	100.0

* 0.5 per cent $(NH_4)_2SO_4$ added.
† 0.5 per cent $(NH_4)_2SO_4$ and 0.5 per cent KH_2PO_4 added.

The aqueous extracts were prepared because it was thought more convenient at first to work with clear media. However, when it became apparent that as a rule results were better with the whole beet crowns, this technique was discarded.

The extracts were prepared by suspending the desired quantity of material in water, adjusting to pH 3.5 and heating in a boiling water bath for 10 minutes with mechanical stirring. The coarse material was removed by filtration through gauze, the pH readjusted to 3.5, and the broth placed on a steam bath for 10 minutes. It was then clarified by using Filter Cel

and suction filtration. This clear extract was adjusted to pH 4.5, distributed into one-liter cylindrical bottles, and diluted to the desired volume with distilled water, then sterilized in the autoclave. The beet crown medium was prepared as follows: 50 grams of ground beet crowns was placed in a one-liter cylindrical bottle, moistened with water, adjusted to pH 4.5 and sterilized in the autoclave. The salts were dissolved in water, the solution sterilized and subsequently added to the sterile crown material to give a volume of 330 ml. In some instances the media were supplemented with $(NH_4)_2SO_4$ and KH_2PO_4, as indicated in Table IV. The inoculum consisted of cells from 10 ml. of a 24-hour culture of the yeast in Difco malt-extract broth. The temperature of incubation in all cases was 30° C.

When the fermentation was completed, the pH was determined and a sample taken to recover the alcohol by distillation. An aliquot portion of the alcohol distillate was analyzed for ethyl alcohol by the method of Osburn, Wood, and Werkman (1933).

Data of experiments with beet-crown extracts and whole beet crown are presented in Table IV. In general, the whole beet-crown preparations presented the most satisfactory results. Supplementing the medium with $(NH_4)_2SO_4$ and KH_2PO_4 did not improve it.

Results

1. Suspensions of dried beet crowns containing 4.0–6.5 per cent of carbohydrate made a satisfactory medium for alcoholic fermentation by yeast.

2. Clarified aqueous extracts of the beet crowns were not as satisfactory as whole beet-crown mashes.

LACTIC ACID FORMATION FROM SUGAR-BEET CROWNS BY LACTOBACILLUS ARABINOSUS

For this work, a strain of *Lactobacillus* was isolated from barley malt in the following manner: A sterile 5 per cent suspension of brewer's malt was inoculated with a small amount of fresh malt and incubated at 55° C. for 48 hours. A sterile 5 per cent corn-meal mash which had been converted with one per cent malt at 55° C. for 2 hours was inoculated with the material noted. After 48 hours the corn-mash culture was plated on Difco tomato-juice agar. Many colonies were examined; colonies consisting of gram-positive, nonsporulating bacilli were transferred to tomato-juice agar by the stab technique and incubated at 37° C. for 24 hours.

A strain selected for the subsequent studies proved on identification to be *L. arabinosus*.[1] The culture was maintained by serial subculturing every 48–72 hours.

Substrates were prepared for fermentation as in the experiments on ethyl alcohol fermentation, except that the pH was adjusted to 6.8 and supplements of malt sprouts, corn-steep liquor, or sugar-beet seed chaff were tested as indicated. Fermentations were carried out in one-liter

TABLE V

LACTIC ACID FERMENTATION OF SUGAR-BEET CROWNS BY L. ARABINOSUS

Substrate	Additions	Time hrs.	Sugar conc. gm./100 ml.	Pct. of sugar fermented	Percentage yield of lactic acid on sugar fermented
Beet-crown extract	0	216	4.20	27.6	92.0
	5 % corn-steep liquor	216	4.35	62.0	106.0
	5 % malt sprouts	144	5.38	94.4	78.0
Whole beet crown	0	215	6.44	78.0	97.7
	5 % corn-steep liquor	215	6.56	92.6	94.4
	5 % malt sprouts	98	7.67	91.5	92.0
	1 % beet-seed chaff	176	5.84	45.0	89.0
	2 % beet-seed chaff	176	6.06	44.0	102.0
	3 % beet-seed chaff	176	6.28	32.7	85.7

cylindrical bottles containing 350 ml. of medium. The temperature of incubation was 37° C., the pH, 6.5. The inoculum consisted of 10 ml. of a 24-hour culture of *L. arabinosus* in a medium of 0.1 per cent glucose and 5 per cent malt sprouts. Twenty-four hours after inoculation $CaCO_3$ sterilized by dry heat was added in sufficient quantity to neutralize the lactic acid which could be formed from the amount of sugar present. Experiments were terminated when there was no more activity, as indicated by reaction of the acid with the $CaCO_3$. The calculated yields of lactic acid are based on the amount of sugar fermented after subtracting the amounts added in the malt sprouts, corn-steep liquor, or sugar-beet seed chaff. Lactic acid was determined by the method of Friedeman and

[1] Thanks are expressed to Dr. Morrison Rogosa, of the Bureau of Dairy Industry, Washington, D.C., for identification of the culture.

Graesser (1933). Unfermented sugar was removed by treatment with copper and lime before analysis was made for lactic acid.

The data presented in Table V are typical of a number of fermentations carried out.

Results

1. Beet-crown extracts fermented poorly, as shown by the long period of incubation and low sugar consumption.

2. During the same incubation period more sugar was consumed when 5 per cent corn-steep liquor was added.

3. In the presence of 5 per cent malt sprouts the sugar was practically all consumed in a shorter period of time, but a low yield of lactic acid resulted.

4. When whole sugar-beet crown medium was used with no supplement, about three fourths of the sugar was consumed in 215 hours.

5. Five per cent corn-steep liquor added to sugar-beet crown effected practically complete sugar utilization in the same length of time.

6. In media containing sugar-beet crowns supplemented with 5 per cent malt sprouts, sugar consumption was almost twice as rapid as that in the same media without malt sprouts. In general, the yield of lactic acid was better with beet-crown media than when an extract of the crown was used.

7. Sugar-beet seed chaff was not satisfactory as a substitute for malt sprouts. At all levels used only about 50 per cent of the sugar was fermented.

BUTYL ALCOHOL-ACETONE FERMENTATION OF SUGAR-BEET CROWNS

The fermentation experiments reported here were carried out with two types of the butyl alcohol-acetone bacteria. The saccharolytic type is regularly selected for making butyl alcohol and acetone from blackstrap molasses industrially. The strain used was one in the laboratory stock collection and was designated B_1 in papers by Reyes-Teodoro and Mickelson (1944, 1945). Considering the nature of the carbohydrate material to be studied, it was expected that the saccharolytic type of organism would be most suitable. The stock culture was perpetuated in soil.

The starch-fermenting organism *Clostridium acetobutylicum* was also maintained in the culture collection and was kept on corn-mash medium. It is typical of the organisms employed in the manufacture of solvents from corn.

In order to prepare the inoculum from the sporulated stock culture

small amounts of the soil infected with the saccharolytic organism and corn mash infected with *Cl. acetobutylicum* were transferred to hot sterile 25 per cent potato mash in two deep culture tubes. After one minute exposure to the high temperature the medium was cooled and incubated 48 hours at 37° C. The vigorously fermenting cultures were then subcultured, the saccharolytic organism to a tube of potato-mash medium and the *Cl. acetobutylicum* to a freshly steamed tube of 6 per cent corn-mash medium. After 24 hours these cultures were tested for their respective abilities to ferment beet-crown media.

The medium for fermentation experiments was prepared as follows: 8.4 grams of sugar-beet crowns was transferred to a 250-ml. prescription bottle, moistened with a small amount of water, and sterilized in the autoclave. The remaining portion of water, containing $(NH_4)_2SO_4$ and KH_2PO_4, as indicated in Table VI, was sterilized separately and combined with the beet crowns after sterilization to bring the volume to 75 ml. Calcium carbonate was sterilized in the oven and added to control acidity. The medium was inoculated as soon as it became cool, and incubated for 72 hours at 37° C.

TABLE VI

BUTYL ALCOHOL FERMENTATION OF SUGAR-BEET CROWNS BY CL. ACETOBUTYLICUM AND A SACCHAROLYTIC STRAIN OF BUTYL ALCOHOL-ACETONE BACTERIA

Substrate	Time hrs.	Gm. sugar per 100 ml.	Pct. sugar fermented	mM. per 100 mM. fermented sugar			Pct. yield total solvents
				Butyl alcohol	Acetone	Ethyl alcohol	
				Cl. acetobutylicum			
Beet crown	72*	5.6	98.8	54.7	32.20	5.80	34.4
	72†	5.6	98.9	44.8	27.40	10.20	29.8
Corn mash	72	4.0	100.0	48.0	36.00	13.70	34.9
				Saccharolytic strain			
Beet crown	90*	5.6	90.2	29.6	3.83	2.01	14.4
	90†	5.6	88.2	23.4	3.06	1.02	11.8
Cane molasses	72†	3.0	100.0	56.3	19.60	6.20	30.7

* $(NH_4)_2SO_4$ in a concentration equal to 6 per cent of sugar.

† $(NH_4)_2SO_4$ in a concentration equal to 6 per cent of sugar; $CaCO_3$ in the same concentration; $CaHPO_4$ in a concentration equal to 0.6 per cent of sugar.

Sugar analyses were carried out, as previously stated, and butyl alcohol, ethyl alcohol, and acetone were estimated after oxidation with potassium dichromate and sulfuric acid, according to the partition method of Osburn, Wood, and Werkman (1933).

Table VI shows typical fermentation data with the two types of butyl alcohol–acetone bacteria on sugar-beet crown media, and the substrates on which they are most commonly used, cane molasses for the saccharolytic type and corn mash for the starch-fermenting type.

The typical yield of solvents (combined butyl and ethyl alcohols and acetone) on cane molasses or corn is 28–32 per cent. Only from molasses is this yield attained with the saccharolytic organism. Furthermore, the sugar-beet crown medium was not as rapidly fermented as cane molasses by the saccharolytic butyl bacteria. It is difficult, in view of the rather simple nutritive requirements of these organisms (Reyes-Teodoro and Mickelson, 1945), to explain this on the basis of lack of essential nutrient factors. Biotin is the only vitamin required by these bacteria. In a purely synthetic medium it is needed only in a concentration of 0.001 microgram per ml. of medium. The vitamin content of sugar-beet crown, though low, in the amount used should have provided an adequate amount of this factor. It seems more likely that some inhibitory factor is present in the sugar-beet crown. This reasoning is supported by the data obtained with the starch-fermenting organism *Cl. acetobutylicum* on sugar-beet crowns and corn mash. Apparently the starch-fermenting organism is not hindered by anything present in sugar-beet crowns, as the yield of solvents and the fermentation rate on beet-crown media are as good as that in corn mash. In addition, it is well known that the growth requirements of these bacteria are more complex than those of the saccharolytic forms. They need, in addition to biotin, para-aminobenzoic acid (Lampen and Peterson, 1943). It appears that organisms of the *Cl. acetobutylicum* type would be most suitable for fermentation of sugar-beet crowns.

Results

1. The saccharolytic type of butyl-acetone bacteria does not ferment sugar-beet crowns as rapidly as cane molasses, and the yield of solvents is only one third to one half that obtained from molasses.

2. It is suggested that the sugar-beet crowns contain something inhibitory to these bacteria.

3. The organisms of the *Cl. acetobutylicum* type ferment sugar-beet

crowns as readily as they do corn mash, and the yield of solvents is equal to that obtained from corn mash.

4. *Cl. acetobutylicum* is the organism of choice for butyl-acetone fermentation of sugar beet-crown media.

SUMMARY AND CONCLUSIONS

1. Sugar-beet crowns, sugar-beet molasses, and sugar-beet diffusion juice have been studied in the 2,3-butylene glycol, ethyl alcohol, lactic acid, and butyl alcohol-acetone fermentations.

2. Under the conditions of the experiments, sugar-beet crowns were readily fermented and gave high yields of products in all but the 2,3-butylene glycol fermentation. Growth was good, but yields were low in the latter.

3. It was necessary to supplement the medium with 5 per cent malt sprouts for good fermentations with *L. arabinosus*.

4. This work demonstrates, with the organisms studied, that sugar-beet crowns do not contain any substances that hinder the growth of the microorganisms concerned except, possibly, that of the saccharolytic butyl alcohol-acetone bacteria.

5. The technique for preserving the beet crowns was simple. There is no doubt that a syrup could be prepared, if desired, which would provide equally good fermentation carbohydrate.

6. Aqueous extracts of beet crowns as prepared by us did not ferment as readily as whole beet-crown media.

7. The present trend in fermentation industries is to recover the non-carbohydrate residues of microbial fermentations to use for their nutrient value. It is highly probable that the residues of sugar-beet crown fermentations would be of good nutritive value, comparable to residues of corn-mash fermentations. Sugar-beet crowns are a good source of B vitamins, as shown previously in unpublished data.

8. The trials are sufficiently convincing to show that there need be no hesitation in recommending the use of sugar-beet crown carbohydrate as a substrate for general use in the fermentation industries.

LITERATURE CITED

1. Friedeman, R. E., and Graesser, J. B. 1933. The Determination of Lactic Acid. Journ. Biol. Chem., 100: 291–308.

2. Lampen, J. O., and Peterson, W. H. 1943. Growth Factor Requirements for Clostridia. Archiv. Biochem., 2: 443–449.

3. Mickelson, M. N., and Werkman, C. H. 1938. Influence of pH on the Dissimilation of Glucose by Aerobacter indologenes. Journ. Bacteriol., 36: 67–76.

4. Osburn, O. L., Wood, H. G., and Werkman, C. H. 1933. Determination of Formic, Acetic, and Propionic Acids in a Mixture. Ind. Eng. Chem., Anal. Ed., 5: 247–250.

5. Reyes-Teodoro, R., and Mickelson, M. N. 1944. Growth Factor Requirements of Three Saccharolytic Butyl Alcohol-Acetone Bacteria. Archiv. Biochem., 4: 291–292.

6. —— —— 1945. Growth Factor Requirements of Saccharolytic Butyl Alcohol-Acetone Bacteria. *Ibid.*, 6: 471–477.

7. Rogers, Dexter, and Mickelson, M. N. 1948. Vitamin B Content of Sugar Beets and By-products. Ind. Eng. Chem., Ind. Ed., 40: 527–529.

8. Shaffer, P. A., and Somogyi, M. 1933. Copper-iodometric Reagents for Sugar Determination. Journ. Biol. Chem., 100: 695–713.

9. Stark, W. H., Adams, S. L., Scalf, R. E., and Kolachov, P. 1943. Laboratory Cooking, Mashing and Fermentation Procedures. Ind. Eng. Chem., Anal. Ed., 15: 443–446.

10. Ward, G. E., Pettijohn, O. G., and Coghill, R. D. 1945. Production of 2,3-Butanediol from Acid-hydrolyzed Starch. Ind. Eng. Chem., Ind. Ed., 37: 1189–1194.

DORMANCY AND GERMINATION OF SEEDS OF THE BUR REEDS, *SPARGANIUM SPP.* *

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THE bur reeds, *Sparganium spp.*, comprise a widespread group of aquatic plants. At times they may be of considerable importance as sources of food for waterfowl (1, 4, 6). Some of the larger forms, such as *Sparganium eurycarpum,* may furnish shelter for waterfowl during the nesting season. The bur reeds propagate vegetatively by rhizomes and also by seeds. Attempts to establish new stands by use of seeds have often been disappointing (4) owing to the slow and irregular germination. The following discussion is a report on observations made by the writers on the germination, viability, and dormancy of seeds of certain species of Sparganium. Those studied were *S. minimum* Fries., *S. chlorocarpum* Rydb., *S. americanum* Nutt., *S. fluctuans* (Morong) Robinson, and *S. eurycarpum* Engelm. Most of the seeds were collected in the vicinity of Orono, Maine; a few were gathered in southern Maine near Newcastle.

STRUCTURE OF THE FRUIT

The "seed" of Sparganium is in reality a dry fruit or nutlet. In most species the pistil consists of a single carpel. In *S. eurycarpum,* however, about 60 per cent of the fruits examined had two seeds, 30 per cent had one, and 10 per cent had three. The pericarp consists of a corky outer layer and a hard lignified endocarp. The stony endocarp completely encloses the seed except for a narrow opening at one end. It is through this pore that the embryo emerges in germination.

The structure of the seed proper has been described in detail by Camp-

* Most of the observations here reported were made at the Botany Department, University of Maine, but some work was done at the Botany Department, Michigan State College.

bell (2). Briefly, the seed consists of an outer layer of nucellus tissue which forms the integuments, a starchy endosperm, and an elongated, cylindrical embryo embedded in the endosperm. The integuments are enlarged at the micropylar end of the seed in such a way as to form a characteristic cap ("Samendeckel" of Hegelmaier, 3) so as to plug the opening or pore of the endocarp. The embryo consists of an elongated cotyledon and a short radicle and plumule. The structure of the various parts of the fruit is illustrated in Figure 1.

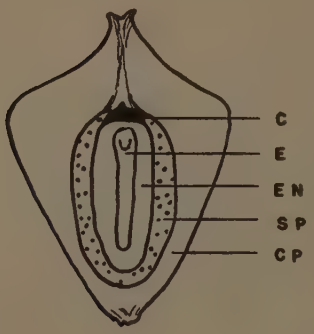

FIG. 1. Diagram of fruit of *Sparganium eurycarpum*, longitudinal section. × 10. Abbreviations: *C*, micropyle cap; *E*, embryo; *EN*, endosperm; *SP*, stony pericarp; *CP*, corky pericarp

GERMINATION

During germination the cotyledon elongates and thus forces the growing point of root and stem through the pore of the endocarp and corky pericarp. The basal end of the cotyledon remains embedded in the endosperm for several weeks, acting as an organ for absorption of food from the endosperm. Stages in seedling development are evident in Figure 1 of Plate I.

VIABILITY

In common with the seeds of many other aquatic plants Sparganium seeds retain their vitality best when they are stored in water. Observations on excised embryos of several lots of seed indicated that vitality may be maintained at a high level for as long as a year at 30° C., for at least two years at 20° C., and much longer at lower temperatures. Thus Muenscher (5) obtained high germination (80–90 per cent) in seeds of *S. eurycarpum*, *S. chlorocarpum*, and *S. americanum* after five years storage in water at 1–3° C.

DORMANCY

The seeds of Sparganium ordinarily do not germinate until several months or years after maturity, depending on storage conditions. The data in Table I indicate the scanty germination of seeds of *S. eurycarpum* during the first three months after maturity.

The question arises whether dormancy is due to the condition of the embryo or to limitations on growth imposed by the tissues external to it. In order to obtain information on this point various portions of the fruit and seed coats were removed. In some of the fruits the pericarp was cut through at the base; in others, through the side; and in still others, through the apex as far as the micropylar plug or cap. In none of them was germination improved. When, however, the micropyle plug or cap was cut, elongation of the embryo commenced almost at once. By this procedure it was possible to obtain germination even in green, freshly harvested fruits, as illustrated in Figures 1–5 of Plate I.

TABLE I

PERCENTAGE OF GERMINATION OF SEED OF S. EURYCARPUM AT THE END OF THREE MONTHS AFTER HARVEST

Temperature of germinator	*Percentage of germination**
5° C. continuous	0
20° C. continuous	0
20°–30° C.†	1
30° C. continuous	0
5°–30° C.†	9

* Based on 5 lots of 100 seeds each.

† Sixteen hours at the lower temperature and 8 hours at the higher temperature.

Although certain storage temperatures shorten the time required for germination of the intact seeds, the favorable effect of these temperatures can hardly be explained on the basis of changes in the embryos. Excised embryos from freshly harvested fruits developed as rapidly as those from seeds stored for a year at 5° C. and 20° C.

It thus appears that failure of the seeds to germinate can be largely attributed to mechanical resistance of the micropylar cap to expansion of the embryo.

METHODS OF OVERCOMING DORMANCY

Although cutting the pericarp and micropylar cap will induce germination and may be used as a quick test for viability, it is hardly suited to

large-scale operations. Immersing the seeds in concentrated sulphuric acid for a few minutes was partially successful in inducing germination. The close proximity of the embryo to the seed coat made it very difficult, however, to avoid injury to the embryo. Treating the seeds with various concentrations of aqueous solutions of thiourea and ethylene chlorohydrin was also ineffective in hastening germination.

The temperature at which the seeds are stored is an important factor in determining the time required for germination of intact seeds. Temperatures compared were 5° C., 10° C., 20° C., 30° C., and various alternations of these. The most effective storage temperature was 20° C. for six to eight months followed by one month at 5° C. Storage of the seeds at temperatures of 20° C. or lower for a year or more also favored germination.

OPTIMUM CONDITIONS FOR GERMINATION

The optimum temperature for germination of Sparganium varies with the conditions under which the seeds have been stored. In every test daily alternations of temperature were much more effective in promoting germination than constant temperatures. For most lots of seed a daily alternation of 5°–30° C. increased the rate of germination and the total percentage of germination over other temperatures. Seeds stored for a year or longer at 5° C. were less exacting in temperature requirements, but even here the highest total germination was at 5°–30° C. The extent to which the percentage germination will vary with the temperature of the germination chamber is illustrated in Table II.

TABLE II

EFFECT OF TEMPERATURE ON GERMINATION OF SEEDS OF S. EURYCARPUM

Storage temperature	Germination temperature	Total percentage of germination by weeks *											
		1	2	3	4	5	6	7	8	9	10	11	12
One year at 20° C.	20° C.	0	0	0	0	0	0	0	0	0	0	0	0
	30° C.	0	0	0	0	0	0	0	0	0	0	0	0
	20°–30° C.†	0	0	0	0	0	0	0	0	9	10	10	10
	5°–30° C.†	0	0	1	10	17	22	27	31	34	36	43	44
One year at 20° C., then two weeks at 5° C.	20° C.	0	0	0	0	0	0	0	0	0	0	0	0
	30° C.	0	0	0	0	0	0	0	0	0	0	0	0
	20°–30° C.†	0	0	0	0	1	1	4	8	8	9	9	9
	5°–30° C.	0	0	7	31	41	49	58	66	68	69	70	70

* Based on 5 lots of 100 seeds each.

† Sixteen hours at the lower temperature and 8 hours at the higher temperature.

SUMMARY

1. Dormancy and irregular germination of Sparganium seeds are the result of restrictions to growth imposed on the embryo by the enveloping seed and fruit coats.

2. Cutting the seeds so as to remove the micropyle cap induced germination in freshly harvested seed as well as in those stored for some length of time. The method may be used as a rapid test for viability.

3. Sparganium seeds remain viable for a number of years when kept moist at low temperatures. Storage temperatures above 20° C. are not recommended. Storage of seeds in the moist condition at 20° C. for six to eight months followed by one month at 5° C. proved to be the most effective storage treatment.

4. Sparganium seeds are exacting in temperature requirements for germination, especially within the first few months after harvest. A daily alternation of 16 hours at 5° C. and 8 hours at 30° C. gave much higher germination than other combinations of alternating temperatures or constant temperatures.

LITERATURE CITED

1. Aldous, C. M., and Mendall, H. L. 1940. Game Birds of Maine. University of Maine, Extension Bulletin No. 275.

2. Campbell, D. H. 1899. Studies on the Flower and Embryo of Sparganium. Proc. Calif. Acad. Sci., Third Series, Botany, 1: 293–328.

3. Hegelmaier, F. 1874. Zur Entwicklungsgeschichte monokotyledoner Keime nebst Bemerkungen über die Bildung der Samendeckel. Bot. Zeitung, 32: 648–655.

4. Martin, A. C., and Uhler, F. M. 1939. Food of Game Ducks in the United States and Canada. U. S. Dept. Agric. Tech. Bull. No. 634.

5. Muenscher, W. C. 1941. Unpublished data. Cornell University.

6. Stickney, Jos. S., Mendall, Howard L., Gashwiler, Jay S., and Marsh, Joel W. 1940. Duck Survey Report No. 1. Maine Department of Inland Fisheries and Game.

PLATE I

Germination of fruits of *Sparganium eurycarpum*

FIG. 1. Freshly harvested fruits. FIG. 2. Fruits five hours after cutting through micropylar plug. FIGS. 3–5. Seedlings five, ten, and fifteen days after cutting

FORESTRY

SOME RESUPINATE POLYPORES FROM THE REGION OF THE GREAT LAKES. XX*

DOW V. BAXTER

THE treatment of polypores ranges from purely arbitrary listings to the involved classifications based upon both morphological and physiological characteristics, as exemplified by some of the more recent papers. In this study it is hoped to include not only these features, but, at least for fungi of economic significance, descriptions of the ecological factors that favor their growth. Control measures must, as a logical corollary, modify the complex of conditions most favorable for these fungi toward those less favorable.

The majority of the resupinate polypores from the region of the Great Lakes have been found to be widely spread over the continent, in varied environments and on a number of different types of substrata. The many additional records of distribution and kinds of substrata that have been made for practically all the species published since the first number of this series was printed over twenty years ago will be included in a revision under the title "The Resupinate Polypores of North America."

The present paper includes accounts of six fungi. *Poria atrorubens* is described as a new species.

The color terms enclosed in quotation marks are those of R. Ridgway, *Color Standards and Color Nomenclature* (1912).

* Throughout the work on these monographs (2) I have been indebted to many individuals and institutions for suggestions, help, and privileges extended to me. Grants from the Horace H. Rackham School of Graduate Studies of the University of Michigan have greatly facilitated both the field and the laboratory studies. My appreciation is expressed particularly to the men who have accompanied me on my numerous expeditions to Alaska, the Yukon Territory, the Northwest Territories, Newfoundland, and Labrador. Much credit is due them for aiding in the collection and care of specimens and for living, at times, under rather difficult circumstances. I am under obligation to Professor T. G. Halle of Naturhistoriska Riksmuséet in Stockholm, with whom I have had the pleasure of association. Thanks are also due to several American institutions and scholars. To the authorities at the New York Botanical Garden, to the staff of the Division of Pathological and Mycological Collections of the United States Department of Agriculture, and to Professor H. H. Bartlett, of the University of Michigan, I am especially indebted.

Poria atrorubens sp. nov.

(Plate I)

Type:

Poria atrorubens sp. nov., on *Liquidambar Styraciflua*, Hot Springs, Arkansas. Coll. Dow V. Baxter, Harold Wise, and Thomas C. Sage, Jan. 30, 1948. Herb. Dow V. Baxter, Ann Arbor.

Fructificato annua, effusa in longitudinem usque ad 50 cm., 1.5 cm. crassa (viva vel sicca), fragilis (sicca) nec cartilaginea nec suberosa, saepe inconspicua in trunco ferrugineo sed isolata conspicua propter colorem primum albidum demum atrorubentem; margine plerumque minus quam 1 mm. lato, cito fertili, concolori cum tubis; subiculo minus quam 0.3 mm. crasso mox evanescenti; tubis plerumque 0.5–1.0 cm. longis, primum albidis vel in plantis cito siccatis, sed plerumque in plantis maturis rubrobrunneis, aetate cinnamomeis vel pallide brunneis; aperturis plerumque 2–3 in uno mm.; tubis concoloribus, sporis breviter cylindricis, 1.5–2 × 4 μ; hyphis hyalinis vel brunneis, plerumque 2–4 μ diametro; fibrillationes absunt. Specimen typicum legerunt Dow V. Baxter, Harold Wise, et Thomas C. Sage, Jan. 30, 1948, Hot Springs National Park, Hot Springs, Arkansas; in herbario auctoris conservatum sub numero 23167.

Fructification annual, fleshy, effused for 0.5 meter or more in elongated patches, up to 1.5 cm. thick when fresh and remaining so in herbarium specimens, dried plants crisp, definitely not horny or corky, often difficult to detect on logs because of predominating brown-red color, but conspicuous by itself because of its garnet color, which develops in the field while fresh and upon bruising; margin mostly less than 1 mm. wide, soon becoming fertile and soon disappearing, concolorous with the tubes; subiculum less than 0.3 mm. wide and soon disappearing; tubes mostly 0.5–1.0 cm. long, whitish at first and patches remaining so if dried suddenly, but mostly soon becoming "garnet brown" and eventually "cinnamon drab" to "army brown"; mouths mostly 2–3 to a mm., concolorous with tubes; spores short-cylindrical, 1.5–2 × 4 μ; hyphae hyaline or brown, mostly 2–4 μ in diameter; clamp connections present.

Allied species.—*Poria atrorubens* is distinct from the few fungi that change color upon maturing, bruising or drying to red. The most common representative of this group is *Poria spissa* (Schw.) Cooke, but it is brilliant yellow or orange before turning to red. *Poria atrorubens* is white at first, thus being different from the red fungi that change from

orange or yellow. When plants are brought into the laboratory and dried suddenly, areas remain white, even suggesting the growth of a mold on the surface. The spores of *P. spissa* are narrower than those of *P. atrorubens,* being 4–5 × 1 μ.

Poria sanguinolenta (A. & S.) Cooke, as interpreted in this series of studies, is even more fragile upon drying than *Poria atrorubens.* It is white at first, as is *P. atrorubens,* but the spores *of P. sanguinolenta* are wider than those of *P. atrorubens,* being 4–5.5 × 3.5–4 μ. *P. atrorubens* is also a thicker plant and often exhibits some of the original whitish appearance when suddenly dried. *P. sanguinolenta* becomes much thinner upon drying, whereas the new plant retains the thickness of the fresh specimen in the herbarium.

Poria aurantio-carnescens (see Pl. II for type specimen in Stockholm) should be compared with it because its spores are 4 × 1.5–2 μ. This is definitely a much thinner plant than *P. atrorubens,* and is more closely related to *P. spissa.* The spores of *P. aurantio-carnescens* are only slightly wider than those of *P. spissa.*

Habitat. — *Liquidambar Styraciflua.*

Distribution. — Arkansas.

Occurrence. — On badly decayed red-gum log.

Poria megalopora (Pers.) Bres., in Atti Ac. Agiati III, 3 : 18. 1897

Fomitiporia ohiensis Murr., North Am. Fl., 9 : 11. 1907.

Phellinus cryptarum Karst., ex specimen from Herbarium in the Forest Products Laboratory; not *Polyporus cryptarum* (Bull.) Fr. recorded by Rea ex Cartwright and Findlay, Decay of Timber and Its Prevention, p. 203. 1946.

Polyporus expansus Desmazières, 1823 (non Fries, Epicr. Myc., 475. 1838), teste Donk, Medd. Bot. Mus. Utrecht, 9 : 228. 1933.

Polyporus megaloporus Pers., Myc. Eur., 2 : 88. 1825.

Poria spongia Quél., Ass. Fr., p. 5, pl. 11, fig. 19. 1891.

Type, cotype, and important specimens examined:

Polyporus megaloporus Pers., fragment "exempl. origin!" Herb. of Persoon, Herb. of Bresadola, Stockholm.

Polyporus megaloporus Pers., Herb. of Persoon, Leiden.

Poria undata Quél., Normandie, France, on Quercus, Quél., Herb. of Bresadola, Stockholm = *Poria megalopora* (Pers.) Bres.

Poria spissa Schw., ex Ellis, on dead trunks, Ohio. C. G. Lloyd = *Poria megalopora* Pers., det. Bresadola; Herb. of Bresadola, Stockholm.

Poria unita Pers., "frag. type" Persoon. Herb. of Bresadola(?), Stockholm.

Fomitiporia ohiensis Murr., on hardwood logs, Ohio. Herb. New York Botanical Garden, New York.

Fructification coriaceous, often effused for 10 cm. and occasionally in sheets, sometimes up to 2 meters in extent, separable; margin subiculose, "smoke gray" and concolorous with the pores; 0.5 mm. thick, soon becoming fertile; subiculum conspicuous, spongy, up to 4 mm. thick, mostly 0.5 mm., "snuff brown," subglistening; tubes "wood brown," 1–7 mm. long, usually 4–5 mm. each season, often oblique and sometimes indistinctly stratified in 2–4 layers; mouths "drab," subrounded to angular, 4–5 to a mm.; dissepiments rather thick, basidiospores hyaline but pale cream in mass, obovate-elongate, 4–6 × 2.5–3 μ; hyphae yellow, 2–4.5 μ, mostly 3 μ, no cystidia.

Forms. — Depending upon position, a broad-plate growth form "tending towards a bracket shape" has been described by Cartwright and Findlay (5): "The fruiting body may reach 14–20 cm. long, 12 cm. high, and about 2.5 cm. thick. Several pore layers may be present. The fruit body is generally very hard and woody, usually with a thin, hard, woody context — 'warm buff' to 'ochraceous buff' or 'buckthorn brown.' Tubes up to 19 mm., 'Sudan brown' to 'argus brown'; pore surface 'pinkish cinnamon' to 'dresden' or 'Mars brown,' pores minute, 3–4 to a mm."

The entirely resupinate separable form of thin, leathery texture, with wide shallow pores that produces a culture identical with the form "tending towards a bracket shape" is referred to *Poria megalopora*. No basidiospores have ever been found on sporophores which have been collected or in culture, although basidia are produced. Secondary spores are produced freely.

Allied species. — The texture of *Poria megalopora* might suggest that of *Fomes nigrolimitatus*, but the color is different, *F. nigrolimitatus* being a much darker brown. But the character of the tubes and their arrangement over a spongy context indicate this species. The spores of *F. nigrolimitatus* are cylindric, being 4–6 × 1.5–2 μ, whereas those of *P. megalopora* are obovate or obovate-elongate and are therefore broader than those of the former species.

Habitat. — *Carya sp., Quercus sp.* Also reported in Europe on Castanea.

Distribution. — Ontario; Ohio.

Occurrence. — Rare in North America. This plant is not common in Europe, although it apparently causes considerable damage locally. It has been reported on structural timbers in England. It attacks wood used in bridges, props, and posts, lofts, oak flooring, and window sills.

Cultures. — Isolated by Cartwright and Findlay (5), who have described the cultures. Mat woolly, at first white, but in the light a cream color appears, becoming "maize yellow" to "cream buff" and "Mars yellow."

Fructifications form in cultures kept in the light. Pore layers become stratified. Basidiospores have not been seen, but chlamydospores are frequent in the fruit body. Hyphae, mostly hyaline, measure 2–6 μ in diameter and bear clamp connections. Thick-walled, fibrous hyphae 4–6 μ wide are also described, and they bear thick-walled chlamydospores 5–9 × 8–16 μ.

The rate of growth is moderate, i.e. about 8.5 mm. per day at the optimum temperature, which is about 27° C. The maximum temperature for growth is reported at just over 35° C., and growth is slow at 10° C.

Decay in Cultures. — Rapid decay in oak sapwood (about 35 per cent loss in dry weight in blocks) is caused by *Poria megalopora.* The fungus is said to attack the heartwood more rapidly than do any of the other fungi tested by Cartwright and Findlay (5). *P. megalopora* caused over 10 per cent loss in dry weight in four months at 22° C. All the major components of oak sapwood are decomposed in this white rot simultaneously, according to Campbell and Bryant (3).

Decay: Gross features. — Poria megalopora causes a white stringy rot, which reduces the wood to long, white fibrous strands. Oak wood rotted by *Poria unita* is similar to that decayed by *P. megalopora* (*Phellinus cryptarum* Karst.). Decayed wood is readily crushed, but does not crumble to powder. A thick-matted, yellow to red-brown crust that exudes drops of yellowish-brown liquid is formed on the surface of the wood (5).

Microscopic features. — Hyphae appear in infected oak, ranging in diameter from 2 to 5 μ. Chlamydospores are formed occasionally in the vessels. Clamp connections are likewise produced. Bore holes may be as much as 6 μ in width. Cartwright and Findlay (5) call attention to the statement of Mangin and Patouillard (12) that a remarkable feature of the decay is the complete dissolution of the membrane limiting the bordered pits of the walls, which therefore appear riddled with holes before the rest of the cell wall is dissolved. Often the bordered pits thus set free are so abundant in a mounting medium that they look like accumulations of spores. Medullary rays

resist the action of the fungus longest, and appear as broad lamellae in the decayed tissues.

Importance.—This fungus is not an important one economically in North America. In England, where it goes under the name *Phellinus cryptarum,* it has probably caused more rapid decay of oak in buildings than any other fungus. Since strands are not produced, it cannot spread through brickwork or over inert materials, as does *Merulius lacrymans.*

Campbell and Bryant (3) discuss reasons why wood decayed by this fungus is more favorable than sound wood for the development of the deathwatch beetle, *Xestobrium rufovillosum,* and concluded that it is the softening of the wood, rather than changes in its chemical composition during decay, which renders it more susceptible to attack by insects. It is possible that many reports of infestation by this beetle have followed attacks by this fungus (5). "In the Palace of Versailles, where most of the rot was due to *Phellinus cryptarum,* the deathwatch beetle was also found. Control of the deathwatch beetle may thus largely depend on preventing the occurrence of decay."

Fomes conchatus (Pers.) Gill., Hymen. Fr., p. 685. 1874

Boletus salicinus Pers., in Gmel., Syst. Nat., 2:1437. 1791. Non *Boletus salicinus* Bull. 1789 ex Shope.
Boletus conchatus Persoon, Obs. Myc., 1:24. 1796.
Fomes salicinus (Fr.) Gillet, Ch. Fr., 684. 1878.
Fomes conchatus var. *Lonicerae* Karsten, Hattsv., 2:78. 1882.
Fomes conchatus f. *salicinus* Lloyd, Syn. Fomes, p. 244. 1915.
Ochroporus conchatus (Pers.) Schroeter, P. Schl., p. 486. 1888.
Phellinus salicinus (Pers.) Quél., Fl. Myc. Fr., p. 394. 1888.
Phellinus salicinus var. *Lonicerae* Karsten, Bidr. Finl. Nat. och Folk, 48:334..1889 (non Weinmann, cf. *Ph. Ribis*?), teste Pilát. 1936.
Placodes conchatus (Pers.) Ricken, Vad., p. 224. 1918.
Placodes salicinus (F.) Ricken, Vad., p. 225. 1918.
Polyporus conchatus (Pers.) Fries, Syst. Myc., 1:376. 1821.
Polyporus salicinus (Pers.) Fries, Syst. Myc., 1:376. 1821.
Polyporus loricatus Pers., Myc. Eur., 2:86. 1825.
Poria salicina Lloyd, 9395.
Pyropolyporus conchatus (Pers.) Murr., Bull. Torrey Bot. Club, 30:117. 1903.

Important specimen examined:

Fomes densus. "Loc. France." F. Fautrey cat. no. 35325, Mycological Collections, Washington, D.C.

Fructification effused-reflexed, part conchate, resupinate or rarely undulate, 0–6 × 4–75 × 0.2–3 cm.; surface grayish brown "snuff brown"

to black, irregularly sulcate, becoming incrusted; margin acute, undulating, tomentose, "tawny olive," becoming blackish, as on surface, in resupinate specimens, sterile below; context "clay color," mostly 0.5–7 mm. thick, often containing one or more black lines 1–3 mm. thick; tubes concolorous with the mouths, stratified, 0.5–3 mm. long each season; mouths circular 5–8 to a mm., "Saccardo's umber," "Sayal brown," or "bister"; basidia hyaline, 9–12 × 4–6 μ; spores hyaline, smooth, subglobose to ovoid, 4–6 × 4–5 μ; setae frequent, 6–10 × 10–20 μ; hyphae brown, thick-walled, 2–4 μ in diameter.

Forms. — A number of variants constitute intermediate forms between *Fomes conchatus* and *F. Ribis*. Some of these are attached to living trees (including dead wood on living trees and shrubs), and they appear to be somewhat specific to certain substrata or hosts. These forms, in general, are more closely related to *F. Ribis*. Examples of such plants are: f. *Evonymi* Kalchbr., f. *Crataegi* B. & G. (*F. occidentalis* Overh.?, *Pyropolyporus Langloisii* Nurr.?), f. *Lonicerae* B. & G., f. *Jasmini* Quél., f. *Amelanchieris* B. & G. However, *Fomes conchatus* shows certain tendencies to be more prevalent on some woods, even if they are dead. This fungus is most common on black ash wood in Michigan.

Fomes conchatus densus. — Thick and more or less undulate specimens of *F. conchatus* have been known as *F. densus* Lloyd, figure IV. Many thick resupinate specimens of this fungus are to be found in herbaria, but the form name *F. conchatus densus* is not applied to all of them. Overholts (14) separates *F. densus* from *F. conchatus* by the smaller pores, which are 8–10 to a mm., and by the spores, which, he states, are "pale rusty" and measure 3–3.5 μ in diameter.

Allied species. — *Fomes conchatus* is closely allied to *F. Ribis*. Setae are present in *F. conchatus*, but are absent in *F. Ribis*. The spores of the two are hyaline, though they are more minute in *F. Ribis*, being 2 × 3 μ. Incrustation of the pileus is a variable feature, but, in general, the surface of the pileus in *F. Ribis* is more apt to be soft in mature specimens, whereas the pileus of *F. conchatus* becomes incrusted. *F. conchatus* is the more resupinate. There is little difference in the width of the pore mouths, though in many specimens of *F. Ribis* they are somewhat smaller. The pore mouths of *F. Ribis* range in size from 4 to 9 to a mm.; those of *F. conchatus*, from 4 to 6 to a mm.

The forms of *F. Ribis* i.e. f. *Rosae* Velenovský, f. *Crataegi* B. & G. (*Fomes occidentalis* Overh.?), f. *Lonicerae* B. & G., f. *Jasmini* Quél.,

f. *Amelanchieris* B. & G., and a number of other forms reported on different host or substrata species are to be separated from *F. conchatus* on the basis of the features of *F. Ribis*. The type of host or substratum attacked is usually given as a means of distinguishing the various forms.

Fomes pectinatus (*Pyropolyporus subpectinatus* Murr. and *F. capucinus* as distributed by Rick., according to Lloyd). — *F. pectinatus* is also considered a tropical form of *F. Ribis*. The spores are light brown in *F. pectinatus* and are 3.5×4 μ, whereas in *F. conchatus* they are hyaline and measure $4–6 \times 4–5$ μ. *F. pectinatus* is usually somewhat thinner. Setae are known in *F. conchatus*, but none are reported in *F. pectinatus*.

Fomes conchatus may be mistaken for *F. fulvus*, a species that is apt to be effused-reflexed. *F. fulvus* is ordinarily a thicker plant, occurring on woods of rosaceous genera, chiefly Prunus. *F. conchatus* is characterized by the presence of a black line in the context, whereas no line appears in *F. fulvus*.

The black line does occur in the context of *Fomes nigrolimitatus* Romell, but it grows only on coniferous wood, whereas both *F. conchatus* and *F. fulvus* appear on hardwoods.

Lloyd (11) calls attention to the fact that *Fomes conchatus* resembles *F. torulosus*, which has darker pore mouths and darker, thicker setae.

The conchate pileus of *Polyporus corrosus* (*Inonatus corrosus* Murr.) is often as imbricate as that shown in *Fomes conchatus densus* (cf. Pls. V and VI with Pl. IV), and because of the color of the under surface and the small pore mouths of *Pol. corrosus* it might be confused with *F. conchatus* in the South or in tropical areas. The context of *Pol. corrosus* is spongy or corky, and the surface of the pileus is not incrusted even at maturity.

Habitat. — *Acer rubrum, A. saccharinum, A. saccharum, A. spicatum, Baccharis chalimifolia, B. occidentalis, Betula lenta, Carya sp., Crataegus sp., Evonymus atropurpureus, Fagus grandifolia, Fraxinus americana, F. nigra, F. sogdiana, Hydrangea paniculata, Lonicera segreziensis, Magnolia cerifera, M. virginiana, Malus pumila, Ostrya virginiana, Physocarpus opulifolius, Populus trichocarpa, Prunus serotina, Pyrus lanuginosa, Quercus macrocarpa, Q. virginiana, Rhamnus cathartica, Rhus cobitina, R. vernix, Robinia pseudoacacia, Salix Beb-*

biana, S. longifolia, Sassafras variifolium, Syringa vulgaris, Toxylon pomiferum, Ulmus sp., Viburnum Lentago.

Distribution. — Manitoba, New Brunswick, Nova Scotia, Ontario, Quebec, Saskatchewan; Arkansas, California, Colorado, Connecticut, Florida, Illinois, Indiana, Iowa, Kansas, Kentucky, Louisiana, Maine, Maryland, Massachusetts, Michigan, Minnesota, Missouri, Montana, New Hampshire, New Jersey, New York, North Carolina, North Dakota, Ohio, Pennsylvania, Rhode Island, South Carolina, Tennessee, Texas, Vermont, Virginia, West Virginia, Wisconsin.

Occurrence. — This is a common species in both North America and Europe.

Cultures. — Isolate F. 2571 from "deciduous" wood, La Salle Woods, Montreal, P.Q. Another isolate is reported by Campbell (3), who does not give its source.

The growth of *Fomes conchatus,* which is slow, reaches its optimum at 26° F. Its growth range is restricted, and development is practically inhibited at 31° C. Campbell reports that it can be distinguished from *F. Pini* by temperature relations and from *F. igniarius* "var. *populinus*" by more rapid growth and by its chalky-white mat in early stages and absence of odor. It is described as having "a very pronounced, characteristic sweet, agreeable" odor.

Fomes conchatus gives a positive reaction to tannic acid medium, which indicates that it produces a white rot. The same reaction is exhibited by the allied plant *F. densus.*

Decay. — The rotted wood becomes yellowish and is characterized by black-line formation. In black ash the wood usually splits along the annual rings, so that parts may readily be broken off in concentric pieces.

Polyporus caesius (Schrad.) Fr., Syst. Myc., 1:360. 1821

Bjerkandera caesia (Schrad.) Karst., Hattsv., 2:37. 1874.
Boletus caesius Schrad., Spec. Fl. Germ., p. 167. 1794.
Boletus albidus Sow. (non Schaeffer), Eng. Fung., pl. 226. 1799.
Daedalea gossypina (Moug.) Quél., Fl. Myc., 375. 1889.
Leptoporus caesius (Schrad.) Quél., Fl. Myc., pp. 386, 176. 1886.
Polyporus (Tyromyces) caesiosimulans Atk., Ann. Mycol., 6:61. 1908.
Polyporus gossypinus (Moug.) Fries, Hymen. Eur., p. 566; Rea, B. Basid., p. 609. 1922.
Polystictus gossypinus (Moug.) Léveillé, Ann. Sci., p. 124. 1848.
Polystictus caesius (Schrad.) Big. et Guill., Fl., 2:360. 1913.
Tyromyces caesius (Schrad.) Murr., North Am. Fl., 9:34. 1907.

Fructification annual, sessile or effused-reflexed, dimidiate, or when umbonate attached by width of umbo, or sometimes entirely resupinate, fragile, soft when fresh, turning blue when bruised, 1–5 × 1–8 × 0.5–1.5 cm., ordinarily small, surface sodden, villous-pubescent, azonate; context white, 3–12 mm. thick; context whitish, fleshy tough, soft (brittle when dry), tubes white or "mineral gray," 1–10 mm. long; mouths concolorous with the tubes, averaging 3–4 to a mm.; dissepiments fimbriate, then becoming lacerate, basidia clavate, 10–13 × 4.5 μ; spores smooth, cylindrical to allantoid, hyaline tinged pale slate-gray in mass, 3–5 (6) × 1–1.5 μ; hyphae thick-walled, seldom branched, 2–4.5 μ in diameter, clamp connections present, no cystidia.

Form. — Resupinate specimens have been referred to the form "resupinata" in Europe by Kavina and Pilát (10).

Allied species. — There are no species closely allied to *Polyporus caesius*. This fungus is most likely to be confused with species of the genus Poria only in the young growth stages. Since *Pol. caesius* turns blue when bruised, it can readily be distinguished from the porias.

Polyporus caesius, Pol. setiger, and *Pol. atrostrigosus* (the latter two plants grow in New Zealand) form a natural group, according to Cunningham (6). These three fungi may be separated by the character of the surface of the pileus or by the color of the pore mouths. *Pol. setiger* is a white plant that becomes pallid or ocher gray. The surface is covered with loose radiately arranged coarse-strigose hairs. The surface of the pileus of *Pol. atrostrigosus* is black and densely surfaced with coarse imbricate-strigose tufts of hyphae. The bluish-gray mouths of *Pol. caesius* distinguish this species (6).

Habitat. — *Abies balsamea, A. grandis, A. nobilis, Acer saccharum, Alnus rubra, Betula alba papyrifera, B. lutea, Carpinus caroliniana, Carya sp., Fagus grandifolia, Fraxinus nigra, Hamamelis virginiana, Juglans nigra, Juniperus virginiana, Larix laricina, L. occidentalis, Liriodendron tulipifera, Malus sp., Ostrya virginiana, Picea glauca, P. rubra, P. sitchensis, Pinus monticola, P. ponderosa, P. resinosa, P. virginiana, Platanus balsamifera, P. occidentalis, P. trichocarpa, Pyrus malus, Quercus sp., Rhododendron maximum, Salix sp., Sambucus glauca, Thuja plicata, Tilia americana, Tsuga canadensis, T. heterophylla, Ulmus americana, Umbellularia californica.*

Distribution. — British Columbia, Manitoba, New Brunswick, Nova Scotia, Ontario, Prince Edward Island, Quebec; Northwest Territories, Yukon Territory; Alaska; California, Colorado, Connecticut, District

of Columbia, Florida, Idaho, Kentucky, Louisiana, Maine, Maryland, Massachusetts, Michigan, Missouri, Montana, New Hampshire, New York, North Carolina, Ohio, Oregon, Pennsylvania, South Dakota, Tennessee, Vermont, Virginia, Washington, West Virginia, Wisconsin, Wyoming.

Occurrence.—This species, which has been reported as rare in many parts of the United States, is common on logs of *Populus balsamifera* in Alaska and the Northwest Territories. It grows solitary and was described on pines in Europe. *Pol. caesius* is known in New Zealand.

Polyporus pubescens (Schum.) Fr., Obs. Myc., 1 : 126. 1815

Boletus pubescens Schum., Enum. Pl. Snell., 2 : 384. 1803.
Coriolus pubescens (Schum.) Quél., Fl. Myc., p. 391. 1888.
Coriolus velutinus Quél., Fl. Myc., p. 389. 1888.
Inodermus maritimus Quél., Ass. Fr., 1886, p. 4, t. 9, f. 8, Fl. Myc. 391. 1888. Teste Pilát, 1936.
Leptoporus pubescens Pat., Tax Hymen., p. 84. 1900.
Polyporus Sullivantii Montagne, Ann. Sci. Nat., II, 18 : 243. 1842. Teste Pilát, 1936.
Polyporus velutinus Fr., Hymen. Eur., p. 568. 1874.
Polyporus pubescens var. *Grayii* Cooke, in Overh., Bull., p. 298, Penn. State Coll. Agric. Exper. Sta., p. 26. 1933.
Polystictus velutinus Cooke, Grevillea, 14 : 83. 1886.
Polystictus pubescens Lloyd, Letter 60, p. 12. 1914.
Trametes quercina Lloyd, teste Bresadola, Sel. Myc., 2 : 31. 1926. Teste Pilát, 1936.
Trametes pubescens (Schum.) Pilát. Teste Pilát, 1936.

Fructification sessile, effused-reflexed, coriaceous to fleshy-tough, cuneate or conchate above, 1.5–5 × 2.5–7.5 × 0.3–2 cm., or resupinate; surface of fruiting body chalk white, becoming "cartridge buff," "cream color," villous-tomentose, finely tomentose or almost glabrous, mostly azonate; margin thin, sterile, or fertile below; context white to cream, i.e. "cartridge buff," often drying to "cinnamon buff," averaging 1–4, mostly 3–4, to a mm., edges thin, dentate; basidia 4–5 × 12–15 μ (Pilát); spores hyaline, smooth, cylindrical, or allantoid, 5–6 × 1.5–2 (3) μ; cystidia none; hyphae occasionally branched, 4–8 μ in diameter (Lowe).

Allied species.—*Polyporus pubescens* varies greatly. A smooth form has been recognized both as a separate species, by Lloyd, and as a variety, by Overholts. *Pol. pubescens* var. *Grayii* differs from *Pol. pubescens* in being glabrous. The plant dries uniformly tan.

The pileus of *Polyporus pubescens* is generally white when fresh, but sometimes it is distinctly gray, cinereous, smoky, or brownish, occasionally turning yellowish in drying. In some specimens the pore

mouths may be "pallid mouse gray." This plant has passed under the name of *Pol. velutinus*, a fungus usually found on aspen.

Polyporus zonatus has a pore surface like that of *Pol. pubescens*. It may be separated from *Pol. pubescens* by its more orange-colored pileus. In resupinate specimens this color may be exhibited at the margin. It is generally necessary, however, to have fully matured collections if these plants are to be separated.

Polyporus biformis is also closely related to this species (1). The radiating pileus fibrils of *Pol. biformis* and the large mouths of the tubes will serve to separate it from *Pol. pubescens*. Spores of *Pol. biformis* measure 6–8 × 2–2.5 μ (Lowe). The spores of *Pol. pubescens* are 4–6 × 1.5–2.5 μ. Furthermore, the mouths in *Pol. biformis* are large and often toothed, mostly 1–2 to a mm., whereas in *Pol. pubescens* they are mostly 3–4 to a mm. and do not become toothed. *Pol. biformis* does not show the "pallid mouse gray" pore surface sometimes evident in *Pol. pubescens*, a color which suggests that of *Pol. adustus*.

Habitat. — *Acer saccharinum, Aesculus Hippocastanum, Alnus incana, A. rubra, A. tenuifolia, Betula lutea, B. occidentalis, B. papyrifera, Carpinus caroliniana, Castanea dentata, Fagus grandifolia, Fraxinus sp., Liquidambar Styraciflua, Liriodendron tulipifera, Populus balsamifera, P. grandidentata, P. tremuloides, Prunus nigra, Pyrus Malus, Salix Bebbiana, Vitus sp.*

Distribution. — Alberta, British Columbia, Manitoba, Nova Scotia, Ontario, Quebec, Saskatchewan; Labrador, Newfoundland;[1] Alaska; Connecticut, Idaho, Indiana, Iowa, Kansas, Kentucky, Maine, Massachusetts, Michigan, Montana, New Hampshire, New York, North Carolina, Ohio, Pennsylvania, Tennessee, Vermont, West Virginia, Wisconsin.

Occurrence. — *Polyporus pubescens* occurs most abundantly throughout the ranges of beech and maple.

Cultures. — Isolate 10214 reported by Nobles (13) on *Alnus incana* from Chalk River, Ontario; and isolate F 7531 on *Alnus incana* from Quebec.

Growth is rapid on malt agar and begins as a white cottony mycelium that soon becomes felty and more or less pitted. In isolate F 7531 mycelium grows up the side of the culture dish and forms gray trans-

[1] Labrador and Newfoundland are reported separately because of geographic differences in their floras.

lucent masses without organized pores, but it produces spore deposits there in five-week-old cultures (13).

The fungus gives a moderately strong reaction to tannic acid medium, but no growth occurs on gallic acid agar.

Growth patterns as described by Nobles (13) show no differences whereby cultures of *Polyporus pubescens* and *Pol. hirsutus* can be satisfactorily distinguished.

Polyporus tulipiferus (Schw.) Overh., Wash. Univ. Studies, 3, Pt. I, p. 29. 1915

Boletus tulipifera Schw., Syn. Fung. Car., p. 73. 1818.
Boletus tulipiferae Schw., Schr. Nat. Ges., Leipzig, 1:99. 1822.
Hydnum lacteum Fr., Syst. Myc., 1:412. 1821.
Irpex sinuosa, Fr., Elench. Fung., 1:145. 1828.
Irpex canescens Fr., Epicr. Myc., p. 522. 1838.
Irpex lacteus Fr., Elench. Fung., p. 145. 1838.
Irpex pallescens Fr., Epicr. Myc., p. 522. 1838.
Irpex tulipiferae Fr., Epicr. Myc., p. 523. 1838.
Irpex tulipiferae (Schw.) Fr., Epicr. Myc., p. 523. 1838.
Irpex lacteus subsp. *sinuosus* (Fr.) Bourdot et Galzin, Hymen. Fr., 573. 1928.
Irpex lacteus (Fr.), Hymen. Eur., p. 621. 1874.
Irpiciporus tulipiferae Murr., Bull. Torrey Bot. Club, 32–472. 1905.
Irpiciporus lacteus (Fr.) Murr., North Am. Fl., 9:15. 1907.
Sistotrema lacteum Fr., Obs. Myc., 2:266, f. 6, f. I. 1818.

Important specimen:

Irpex sinuosa Fr. "genuinus" on Betula alba, Siberia, Herb. of Bresadola, Stockholm

Fructification perennial, effused, sometimes for as much as 49 cm. or more, coriaceous, effused-reflexed, pileus white or whitish, 0.7 × 1–5 × 0.3–0.8 cm., or plant entirely resupinate; surface of pileus hirsute, zonate; context white, 0.5–2 mm. thick; margin in resupinate plants sterile, up to 4 mm. wide, white to "pinkish buff"; tubes 1–2 mm. long, white to "pinkish cinnamon"; mouths concolorous with the tubes, rather large, 1–2 to a mm., soon breaking up into teeth, dissepiments becoming lacerate; basidia 3–4.5 × 15–25 μ (Pilát); spores hyaline, smooth, cylindric, 5–6 × 1–2.5 μ; cystidia incrusted, 16–44 × 7–8 μ; hyphae sometimes branched, occasionally incrusted, 4–5 μ in diameter.

Allied species. — Immature specimens of *Polyporus tulipiferus* may suggest *Poria versipora*, but the spores in *P. versipora* are mostly 5 × 3.5 μ, in contrast to those of *P. tulipiferus*, which are cylindric. Very superficial examinations of specimens might lead one to confuse certain specimens of *Radulum caesarium* and also *R. pallidum* with

Polyporus tulipiferus. Upon careful examination generic differences between these plants should be sufficient to separate the species.

A few young resupinate specimens have been collected that might suggest immature plants of *Trametes hispidus*. Even in the resupinate state the borders of *T. hispidus* are brown and much more hispid. The pore surfaces are more clay color than whitish or cream, as in *Polyporus tulipiferus*.

Habitat. — *Acer Negundo, A. platanoides* var. *Buntzelii, A. rubrum, A. saccharum, A. spicatum, Ailanthus glandulosa, Alnus incana, A. nigrosa, Albizzia julibrissin, Amelanchier alnifolia, Amygdalus sp., Aralia spinosa, Betula lutea, B. papyrifera, Caragana arborescens, Carpinus caroliniana, Carya cordiformis, C. glabra, Castanea dentata, Celastris scandens, Cornus florida, Corylus rostrata, Crataegus sp., Fagus grandifolia, Fraxinus americana, F. nigra, F. pennsylvanica lanceolata, Ginkgo biloba, Gleditsia mucrantha, G. triacanthos, Gymnocladus dioicus, Ilex opaca, Juglans cinerea, J. nigra, Liquidambar Styraciflua, Liriodendron tulipifera, Magnolia acuminata, M. glauca, M. virginiana, Malus sp., Morus alba, M. rubra, Pinus ponderosa, Platanus sp., Populus deltoides, P. grandidentata, P. tremuloides, Prunus americana, P. Armeniaca, P. avium, P. Cerasus, P. nigra, P. pennsylvanica, P. Persica, P. serotina, P. virginiana, Pyrus americana, P. aucuparia, P. communis, P. grandis, P. malus, Quercus alba, Q. borealis maxima, Q. Catesbaei, Q. Muehlenbergii, Q. utahensis, Q. velutina, Rhamnus Frangula, R. Purshiana, Rhus glabra, R. toxicodendron, R. typhina, R. vernix, Ribes rotundifolium, Robinia pseudoacacia, Rosa sp., Salix sp., Sambucus racemosa, Sassafras officinale, Sorbus americana, S. Aria, Spiraea Vanhouteii, Syringa vulgaris, Tilia glabra, Ulmus americana, Vitis sp.*

Distribution. — Northwest Territories; Alberta, British Columbia, Labrador, Manitoba, New Brunswick, Nova Scotia, Ontario, Quebec, Saskatchewan; Alaska; Alabama, Arkansas, Connecticut, Delaware, District of Columbia, Florida, Georgia, Illinois, Indiana, Iowa, Kansas, Kentucky, Louisiana, Maine, Maryland, Massachusetts, Michigan, Minnesota, Mississippi, Missouri, Nebraska, New Hampshire, New Jersey, New Mexico, New York, North Carolina, North Dakota, Ohio, Pennsylvania, Rhode Island, South Carolina, South Dakota, Tennessee, Texas, Utah, Vermont, Virginia, West Virginia, and Wisconsin.

Occurrence. — *Polyporus tulipiferus* is widely distributed throughout the Northeast, East, Southeast, and Middle West. It is not so common

in the Rocky Mountains and states to the west. I have frequently seen it on Sambucus in parts of southeastern Alaska.

The fungus commonly attacks dead limbs still attached to trees, and it is usual to find it on fire-killed sprouts. It attacks hardwood timbers in service.

Cultures. — Isolated by the United States Forest Products Laboratory,[2] *Polyporus tulipiferus* has been used as a test organism in a number of greatly different experiments that deal with wood decay and wood preservatives. Other isolates by the Division of Botany and Plant Pathology, Ottawa, Canada, on *Sorbus Aria* F. 8048, Ottawa; on *Prunus Armeniaca* F. 10233, Summerland, British Columbia.

Growth of *Polyporus tulipiferus* is rapid on malt agar. The fungus produces a cottony mat that remains white. It causes a weak or no reaction on tannic acid and gallic acid agars (13).

Hawley, Fleck, and Richards (9) tested the toxicity to this *Pol. tulipiferus* of standard hot and cold water extracts prepared from a wide variety of woods and were able to show a close correlation between the toxicity of the extracts and the resistance to decay of the timbers from which they had been prepared. Hot water extract from such durable woods as mulberry, catalpa, and redwood inhibited the growth of *Pol. tulipiferus*.

Decay. — *P. tulipiferus* causes a white rot.

This fungus has been used as a test organism by Ernest (8) to determine the presence or the absence of natural toxic substances in woods generally reputed to be resistant to fungi. It was found that the substance in the wood wallaba, *Eperua falcata*, contained no material that affected the growth of the fungus. Greenheart, *Ocotea rodioei*, Burma teak, *Tectona grandis*, and cabbage bark, *Lonchocarpus Castilloi*, effectively prevented its development over the sawdust of the heartwood of these species, and Western red cedar, *Thuja plicata*, greatly retarded the rate of growth. Ponderosa pine, *Pinus ponderosa*, likewise retarded the expansion of the mycelium.

Inoculated sections of cottonwood, *Populus deltoides* Marsh, and hackberry, *Celtis occidentalis* L., with material from fruiting bodies, were placed under a greenhouse bench at 85° F. Fruiting bodies of

[2] The fungus isolate called "Madison 517" and once known also under the name "*Fomes annosus*" is identified by Darley and Christensen (7) as *Polyporus tulipiferus*.

Polyporus tulipiferus were produced that were typical of those formed in nature.

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LITERATURE CITED

1. Baxter, Dow V. 1934. Pathology in Forest Practice, Chaps. V–XI. New York: John Wiley & Sons, Inc.

2. —— 1926–47. Some Resupinate Polypores from the Region of the Great Lakes. Pap. Mich. Acad. Sci., Arts, and Letters, Vols. 6–33.

3. Campbell, W. G., and Bryant, S. A. 1940. A Chemical Study of the Bearing of Decay by *Phellinus cryptarum* Karst. and Other Fungi in the Destruction of Wood by the Death Watch Beetle, *Xestobrium rufovillosum* DeG. Biochem., 34:1404–1419.

4. Cartwright, K. St. G., and Findlay, W. P. K. 1938. Principal Decays of Softwoods Used in Great Britain, 106 pp. His Majesty's Stationery Office, London.

5. —— —— 1946. Decay of Timber and Its Prevention. Dept. Scientific and Industrial Research, Forest Products Research Laboratory, Nos. III–VI, 294 pp. London, His Majesty's Stationery Office.

6. Cunningham, G. H. 1948. New Zealand Polyporaceae 3. The Genus Polyporus. Dept. Sci. and Ind. Research, Plant Diseases Division, Bull. 4, 39 pp. Dunedin, N. Z.

7. Darley, Ellis F., and Christensen, Clyde M. 1945. The Culture Designated Madison 517 Identified as *Polyporus tuliperiferus*. Phytopathology, 35:220–222.

8. Ernest, Elizabeth C. M. 1936. A Test for the Presence of Natural Preservative Substances in Wood. Forestry, 10:58–64.

9. Hawley, L. F., Fleck, L. C., and Richards, C. A. 1924. The Relation between Durability and Chemical Composition in Wood. Ind. and Eng. Chem., 15:699–700.

10. Kavina et Pilát. 1936. Atlas des Champignons de l'Europe, Tome III, Polyporaceae I, 624 pp. Prague.

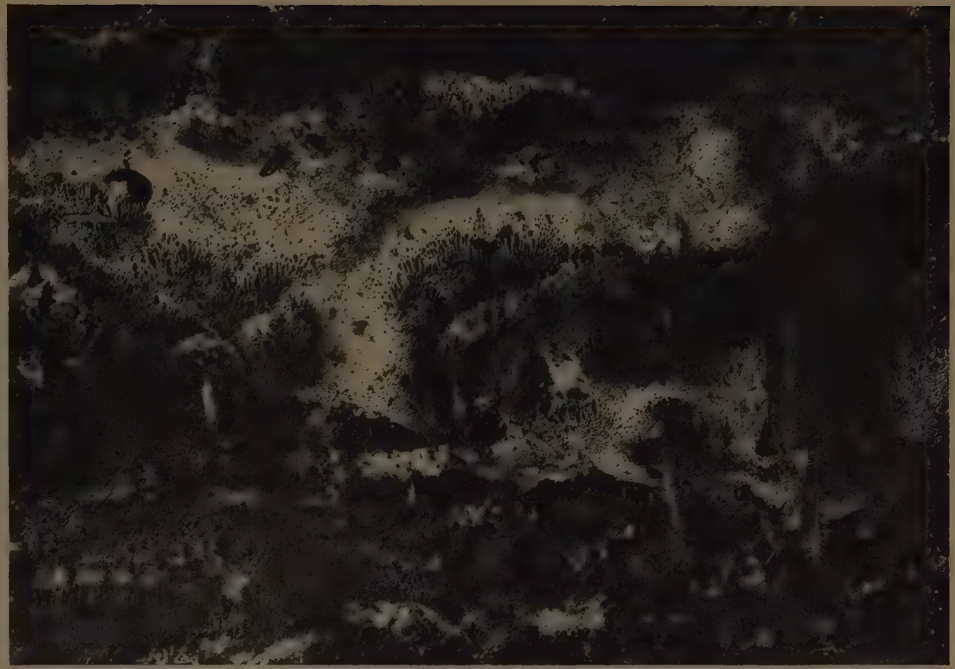
11. Lloyd, C. G. 1915. Synopsis of the Genus Fomes, pp. 211–286. Cincinnati.

12. Mangin, L., and Patouillard, N. 1922. Sur la destruction des charpentes au château de Versailles par le *Phellinus cryptarum* Karst. C. R. Acad. Sci. Paris, pp. 175, 389.

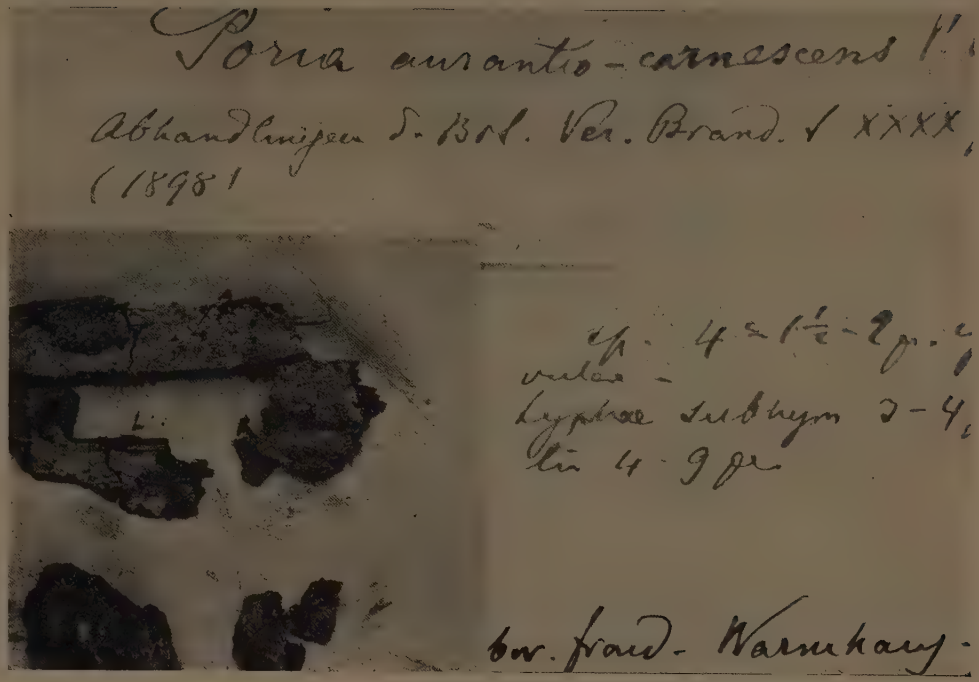
13. Nobles, Mildred K. 1948. Studies in Forest Pathology. VI. Identification of Cultures in Wood-rotting Fungi. Canadian Journ. Res., 26:281–431.

14. Overholts, L. O. 1931. Diagnoses of American Porias III. Some Additional Brown Species, with a Key to the Common Brown Species of the United States and Canada. Mycologia, 23:117–133.

15. Pilát. *See* Kavina et Pilát.



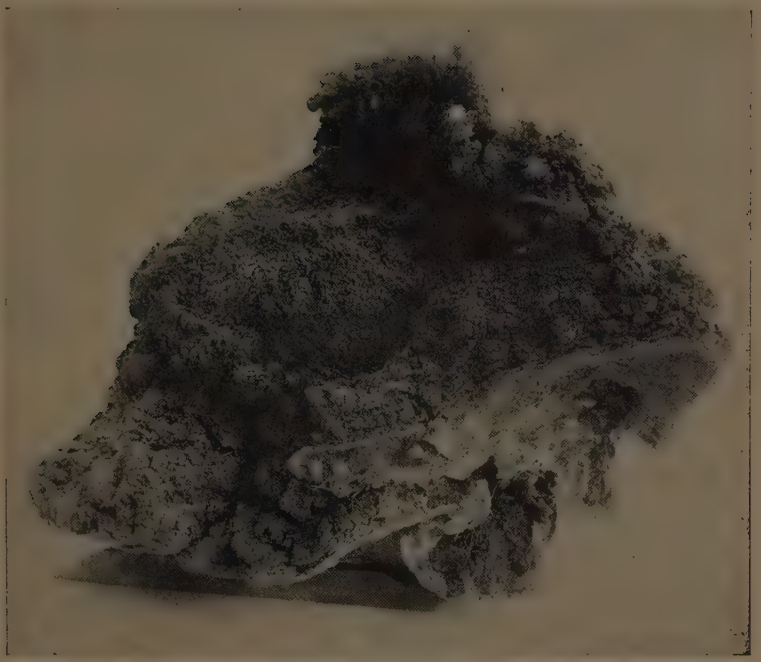
Poria atrorubens sp. nov. on *Liquidambar Styraciflua*, Hot Springs, Arkansas


Poria aurantio-carnescens P.
Abhandlungen d. Bot. Ver. Brand. v XXXX
(1898)
sp. 4 = 1½ - 2 µ.
vulgo -
Lycoperdon subhyem 3 - 4
lin 4 - 9 µ
br. Fraud - Warnhaus

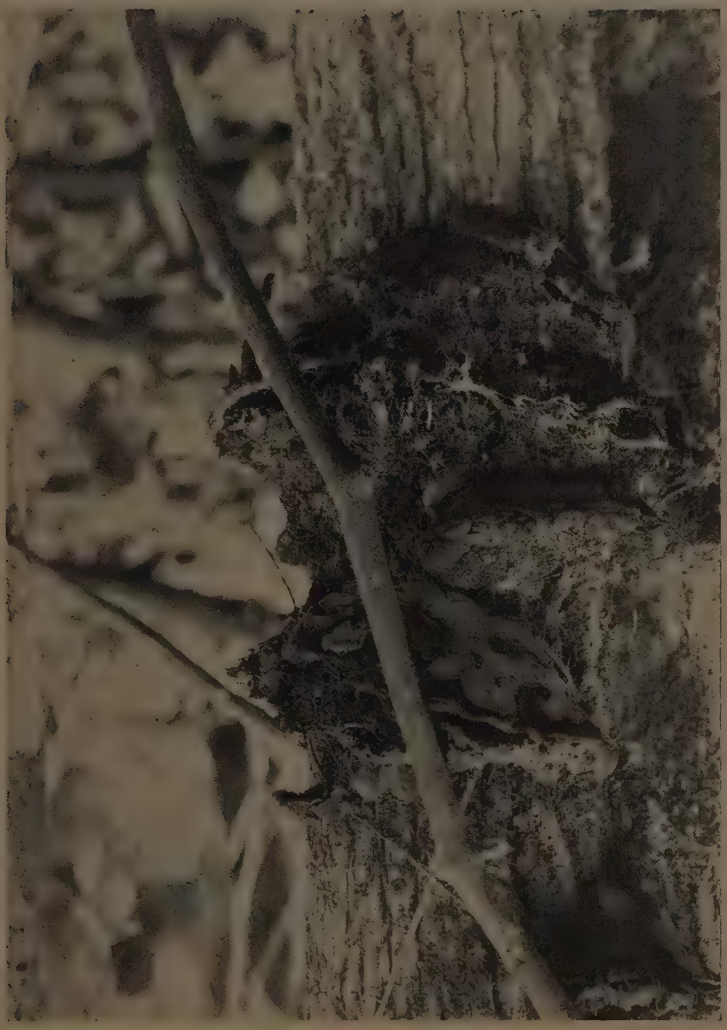
Poria aurantio-carnescens P. Henn. Original example. Spores 4 × 1.5–2 µ
Bresadola Herbarium, Stockholm

FIG. 1. Resupinate form of thick specimen of *Fomes conchatus* on black ash log, Chelsea, Michigan. This is not regarded as the "densus" form of the species

FIG. 2. Thick form of *Fomes conchatus* on black ash log, Chelsea, Michigan. This is not regarded as the "densus" form of the species



Fomes conchatus densus on black ash, standing dead tree, McMillan, Michigan. Note the more or less undulate type of growth



Polyporus corrosus on *Eugenia sp.*, Miami, Florida, September, 1944

Polyporus (*Inonatus*) *corrosus* Murrill on vine, Mona Island, Puerto Rico

VARIATION IN SCOTCH PINE *

PAUL O. RUDOLF

SCOTCH pine was one of the first forest trees to be planted in Michigan, as it was elsewhere in the eastern United States. This was so because many European settlers remembered the common pine of their homeland and because seed and nursery stock were available at a time when those of native species were not. However, the poor form of many of the Scotch pines and the number of enemies injuring them brought this species into disfavor, and native pines largely replaced it in forest planting.

Most of the early plantings of Scotch pine in this country were from central European, largely German, seed. European research since then has shown a great deal of racial variation (in growth rate, branching habit, resistance to diseases and insects, and the like) within this species, which is native over much of northern and central Europe and Siberia. To learn whether some races might produce desirable trees under our conditions the Lake States Forest Experiment Station in 1928 began assembling Scotch pine seed of several sources. Stock grown from this seed was field-planted on the Huron National Forest in Lower Michigan in 1931 and 1932. Because Scotch pine now is in favor for planting to produce Christmas trees and to control erosion, the results of this study should be of interest.

ASSEMBLING THE SEED

From the spring of 1928 to the spring of 1929 Scotch pine seed of twenty origins was collected or purchased. These represented both the northern and the central European types and were obtained partly from American plantations and partly from European stands. Seed of eight more origins was collected during 1930 (Table I). Some collections were from individual trees, some from small groups, some from limited locali-

* Paper from the Lake States Forest Experiment Station, maintained by the U. S. Department of Agriculture, Forest Service, in coöperation with the University of Minnesota, at University Farm, St. Paul, Minnesota.

TABLE I

ORIGINS OF COLLECTIONS OF SCOTCH PINE SEEDS

SEED OF KNOWN OR SUPPOSED CENTRAL EUROPEAN ORIGIN

Collection number	Place of origin	Collection date	Kind of collection*	Character of mother tree			
				Form	Age Years	D.B.H. Inches	Total height Feet
57	Fish hatchery, Wild Rose, Wisconsin	9/28/28	1	Good	15	3	15
58	do.	do.	1	Poor	15	4	20
59	do.	do.	2	Good	15	3–4	20+
68	Monticello, Minnesota	3/24/29	2	Good	20	...	20–25
68B	do.	10/14/28	1	Good	20	...	20–25
69A	1 mile north of Becker, Minnesota	10/14/28	1	Good	19–20	9	30
69B	do.	do.	1	Fair	19–20	8	20
94	Near Ames, Iowa	4/3/29	1	Fair	22	8	25
95	10 miles east of Webster City, Iowa	4/5/29	1	Poor	25	...	25
96	3½ miles southeast of St. James, Minnesota	4/6/29	1	Good	22	7	30
97	1½ miles south of St. James, Minnesota	4/6/29	1	Excellent	30	12	35
98	Portsmouth, New Hampshire	Fall 1927	4	Poor	...	...	...
99	Wittingau, Bohemia	1927?	4	?	...	...	...
100	Austria?	?	4	?	...	...	...
109	1½ miles south of St. James, Minnesota	10/26/29	1	Poor	30	12+	35
128	South-central Europe	?	4	?	...	...	...
129	Germany	...	..	...	...	...	...
251	Near East Tawas, Michigan	9/22/30	2	Fair	23	2.7	14
252	do.	do.	2	Poor	21	5.5	20
253	1 mile south of Tawas City, Michigan	do.	1	Fair	22	8.0	32
254	5.6 miles east of Forest City (Alger County, Michigan)	10/23/30	2	Poor	23	10.5	30
258	5 miles northwest of Becker, Minnesota	3/16/31	2	Poor	30	4–8	25–
186	Great Plains Field Station, Mandan, North Dakota	10/5/30	2	Excellent	16	...	25–

ORIGINS OF COLLECTIONS OF SCOTCH PINE SEED (*Continued*)

SEED OF KNOWN OR SUPPOSED NORTHERN EUROPEAN ORIGIN							
101	Riga variety?	?	4	?	...	...	...
102	Buskerud, Norway	1926	3	Good	...	...	...
113	Falun, Kopperburg, Sweden	1925	4	Good	...	...	...
127	Duna River, Courland, Latvia	1929–30	4	Good	100	...	...
130	Riga variety	1929?	4	?	...	...	...
185	Hurdsfield (Wells County), North Dakota	10/4/30	2	Good	28	4–9	25—
SEED OF ASIATIC ORIGIN							
91	Harbin, Manchuria	1928?	4	?	...	...	...

* 1 = individual tree; 2 = small group; 3 = limited locality; 4 = general and mixed.

ties, and some were general or mixed. The mother trees, according to incomplete information, apparently ranged from 15 to 100 years in age, 3 to 12+ inches in d.b.h., 15 to 35+ feet in height, and poor to excellent in form.

Seed quality was reasonably good.[1] Germination at 40 days in sand flats was from 44 to 96 per cent for the various lots, and the number of seed per pound ranged from 40,100 to 103,800. There seemed to be no particular relationship between seed origin and seed characteristics.

GROWING THE STOCK

Seed of 20 Scotch pine sources was sown in the Cass Lake nursery (Minnesota) in May, 1929, and that of 18 additional sources was sown in May, 1930. Nursery germination and tree per cents were reasonably good for all lots. The stock sown in 1929 was transplanted in May, 1930, and again in May, 1931. Ten lots sown in 1930 to replace shortages in the 1929 sowings were also transplanted in May, 1931.

Stock of the 1929 sowings was lifted as 1–1–1 and that of 10 lots of the 1930 sowing as 1–1 in September, 1931. It was shipped by railway express from Cass Lake, Minnesota, to East Tawas, Michigan, from which it was taken by truck to the planting site (about 40 miles distant). Thirteen lots sown in 1930 were lifted as 2–0 in October, 1932, and shipped to the Michigan planting site in the same manner. All stock arrived in good condition.

FIELD PLANTING

The planting site was a level, open area on Grayling fine sand. Formerly in jack pine, it had been severely burned over in 1927. At the time of planting the area was predominantly in grass (both big and little bluestem being common) with some low growth of sand cherry, bearberry, blueberry, and sweet fern. Such annuals as prairie violets, wild asters, and blazing star were common. Known as the Mack Lake Block, the area is located in the N. $\frac{1}{2}$ of NE. $\frac{1}{4}$ of SW. $\frac{1}{4}$, Section 12, T. 25 N., R. 3 E., Michigan principal meridian.

The ground was prepared by plowing furrows 6 feet apart in subplots 60 feet square. Ten rows, each with 10 trees 6 feet apart, were planted in each subplot by experienced local planters using the bar-slit method. Each row contained trees of one source, except where odd

[1] More detailed information on this and other results can be found in tables which may be obtained from the author.

amounts of stock were used up, in such a way that 100 trees of each seed source were scattered in random 10-tree rows over the area. Seventeen subplots were planted in the fall of 1931 and 11 in the fall of 1932.

NATURE TAKES A HAND

In the summer of 1933 a mild drought in the locality of the planting site caused some mortality. During the summer of 1936 the most severe drought and heat on record occurred in this locality. Moderate losses took place among the pines planted in 1932 and light losses among those planted in 1931. On April 2, 1946, a severe fire, which covered some 5,000 acres, swept through the plantation, and killed almost all the remaining trees.

SURVIVAL RECORDS

Survival counts were made in the spring and fall of each year from 1932 through 1937, and in the summer of 1946. Up to the drought of 1936 survivals were reasonably good (70 to 100 per cent) for the 1931 planting. The 1932 planting suffered more loss in the mild drought of 1933; individual lots had survivals of from 37 to 100 per cent in the fall of 1934.

After 14 years in the field the average survival for all lots planted in 1931 was 82 per cent; that for individual lots ranged from 50 to 97 per cent. The five best lots (upper 25 per cent) included four from known or supposed central European origins (lots 100, 69A, 69B, and 94) and one Asiatic lot. One northern European lot (102) just missed this group, but the others ranked quite low.

The trees planted in 1932 suffered much more loss, for the average survival of all lots at the end of the 13 years in the field was only 38 per cent. Survival in individual lots ranged from 18 to 56 per cent. The three best lots (upper 25 per cent) included two of known or supposed central European origin (lots 186 and 254) and one of supposed northern European origin (lot 130).

SEASONAL GROWTH AND FLOWERING

Beginning in the early summer of 1936 weekly measurements of terminal-shoot development were made of several trees of five different sources among the 1931 planting. Height growth began about the same time for all the different sources and showed the same trends over the season. During the three years of record the average seasonal height growth of the trees from the seed sources examined ranked in this order,

with the largest first: 91, 102, 130, 128, and 59. There were, however, no differences of statistical significance.

On June 1, 1939, observations on the flowering of the Scotch pine showed the following results:

1. Pistillate flowers were numerous on nearly every tree.

2. Staminate flowers were found on but few trees. Out of about 180 trees, 21 had staminate flowers. Of these, 17 were of collection 100 (Austria?), 3 were of collection 95 (central European type, from near Webster City, Iowa), and one was from collection 91 (Manchuria).

3. The majority of the 21 trees had both pistillate and staminate flowers and usually one- or two-year cones. Flowering habit appears to be related to seed source. Similar conditions were noted in 1938, but detailed observations were not taken then.

HEIGHT DEVELOPMENT

The average height of all trees after 14 years in the field was 11.7 feet, with the poorest lot averaging 8.4 feet, and the best, 14.2 feet. The ranking of the lots for average height was different from that for survival. The best lots (97, 58, 59, 94, and 57) were all of known or supposed central European origin. The best lot from northern European sources (102) ranked 13 out of 20, and the single Asiatic lot ranked 16.

For the Scotch pines planted in 1932 the average height was 8.7 feet after 13 years in the field; the various lots ranged from 7.2 to 10.3 feet. Most lots ranked quite differently from what they did on the basis of survival. Lots 254, 186, and 109 were the three best.

DIAMETER DEVELOPMENT

After 14 years in the field the trees planted in 1931 averaged 2.01 inches in d.b.h., with individual lots ranging from a low of 1.21 inches to a high of 2.73 inches. In this respect the ranking of the lots was different from that for survival or height, although there was more similarity in their height. The five best lots (97, 59, 68B, 58, and 57) were all of known or supposed central European origin; the best of the northern European lots (102) ranked 14, and the single Asiatic lot 18 out of 20.

After 13 years in the field the pine planted in 1932 averaged 1.44 inches in d.b.h. The poorest lot (113) averaged 0.98 inch and the best (254) 1.94 inches in d.b.h. The best lots (254, 186, and 109) are of known or supposed central European origin, and the best of the northern European lots (127) ranked 6 out of 13, but some of the central European lots (251 and 252) ranked among the poorest.

BASAL AREA

Survival and diameter growth are combined in the expression "basal area per acre." Since "basal area" often is used as a measure of stocking, it is of interest to compare the various lots on this basis.

Scotch pine 14 years after planting averaged 21.65 square feet, basal area per acre. The poorest lot (113) had 7.00 square feet and the best lot (97), 40.84 square feet per acre. The various lots ranked much as they did for diameter, with the five best lots (97, 59, 58, 68B, and 57) all of central European type. The best northern European source (102) ranked 13 and the single Asiatic source 16 out of 20.

The pine planted in 1932, after 13 years in the field, averaged 4.95 square feet per acre in basal area, with a range of 2.64 to 11.28 for the various lots. Rank was somewhat different from those for other categories, but fairly similar to that for diameter. The three best lots (254, 186, and 109) were of central European type, although the next three (130, 127, and 185) were of northern European origin. The poorest lot (253) is one which appears to be of Alpine origin.

VOLUME

"Volume per acre" is a combined expression of survival and development in diameter and height. Since there are no volume tables for stands as young as these, an approximation of total unpeeled volume in cubic feet was obtained by the formula:

$$Vuc = \left(\frac{d}{2}\right)^2 \cdot \frac{h}{100} \cdot N,$$

where Vuc = unpeeled total volume in cubic feet,
d = diameter at breast height in inches,
h = total height in feet,
N = number of trees per acre.

No factor for form is included, but the formula is adjusted to the average form of Lake States conifers. Volume is the best expression of quantity of material produced by the various lots.

Among the lots planted in 1931 the approximate unpeeled cubic-foot volume per acre ranged from 27 to 270, with an average of 116. The lots ranked in almost the same order that they did for basal area. Those of central European type were best; the highest ranking northern European lot (102) stood fourteenth in twenty, and the single Asiatic lot stood sixteenth.

The total unpeeled cubic volume of the pine planted in 1932 averaged 20 cubic feet per acre, with individual lots ranging from 8 to 55. The order of rank was similar to that for basal area. The three best lots (upper 25 per cent) were all of central European type (254, 186, and 109), but the next three (127, 130, and 185) were of northern European type. The poorest lot (253) was one of apparent Alpine type.

FORM

The trees were tallied not only according to survival, height, and diameter, but also according to vigor, soundness, and form after the Lake States tree classification.[3]

At the end of 14 years in the field about one third of the Scotch pine were of good form. The percentage of trees of good form in individual lots ranged from 10 to 49 per cent. The trees of northern European type generally were better in form than those of central European or Asiatic origin. Some lots contained numerous forked trees, probably as a result of past insect damage. The most common failing was limbiness, which may have been due in part to insect damage, although much of it appears to be a hereditary characteristic. Bent or crooked trees were least common among the trees of northern European origin. This deficiency may also be partly the result of insect damage.

The lots planted in 1932 had the same percentage (29) of trees with good form; from 8 to 58 per cent of the trees in individual lots were of good form. Limby trees made up the largest group of those with unsatisfactory form. Forked, bent, or crooked trees were less common.

VIGOR

Tree vigor is expressed partly by position in the stand and relation to surrounding trees and partly by crown density. In this case crown density could not be determined accurately because of fire damage, so that the trees had to be rated only on position and relation to surrounding trees.

At the end of 14 years in the field about one sixth of the trees were dominants or codominants competing with trees of equal or poorer development. Individual lots contained from 0 to 37 per cent of satisfactory trees. The lots of northern European type in general rated somewhat better than those of central European type.

[3] Gevorkiantz, S. R., Rudolf, Paul O., and Zehngraff, Paul J., "A Tree Classification for Aspen, Jack Pine, and Second-Growth Red Pine," *Journ. For.*, 41(1943): 268–274.

The pines planted one year later were poorer, for only about 10 per cent of them were satisfactory. Individual lots had from 0 to 18 per cent of satisfactory trees. Though the best lot was of northern European origin, the next six were of central European type.

SOUNDNESS

The pines planted in 1931 were 70 per cent sound at the end of 1945. Among the various lots from 59 to 100 per cent of the trees were sound. Aside from fire, which killed all but a few trees in the spring of 1946, the most common cause of injury (sufficient to affect soundness) was the white-pine weevil. Many trees were injured by gall rust, and smaller numbers by the pitch nodule maker, the root-collar weevil, deer browsing, competition, snow breakage, and porcupines.

The relative growth in height and diameter varied with the kind of injury. Trees of northern European sources were not injured by the pitch nodule maker, root-collar weevil, or deer. Trees of Asiatic source were free of serious injury by these agencies and also by competition, gall rust, and porcupines. As a general thing, trees injured by the white-pine weevil and gall rust were about the same size as those uninjured; trees injured by porcupines were larger than those uninjured, and those affected by the pitch nodule maker, root-collar weevil, deer, competition, and snow breakage were smaller. A large part of the trees classed as sound had been attacked by the white-pine weevil at some time.

The pines planted in 1932 were 98 per cent sound. Most of the lots had all sound trees; the poorest (109) had 88 per cent. The few injured trees had been attacked by the root-collar weevil or the white-pine weevil, and most of the sound trees had been damaged by the latter weevil at some time. The injured and the uninjured trees averaged about the same in height and diameter.

PREMIUM TREES

The trees which have the best chance of coming through to maturity as valuable crop trees are the head and strong dominants which are sound and of good form. Seven per cent of the trees planted in 1931 were premium trees; some lots had none and others as many as 20 per cent. The best lot (127) was of northern European origin, but the rest of the top five (upper 25 per cent) were of central European type (69B, 94, 100, and 98). Only 4 per cent of the pines planted in 1932 were premium trees. Some lots had no premium trees, and the best had only 11 per cent. The

best lot (130) in this group also was of northern European origin, with the next two (making up the top 25 per cent) of central European type (109 and 252).

EVALUATING THE RESULTS

The purpose of these tests was to show the suitability of various sources of Scotch pine for the Huron National Forest locality. Two kinds of measures have been used to evaluate the different sources: quantity and quality.

The measurements of quantity are perhaps best expressed as cubic volume per acre, since this value combines the effects of survival and growth in height and diameter in proper degree. The factors of quality measured were vigor, form, and soundness. These various components of quality probably are not of equal weight. What their relative weights should be is difficult to determine. There is even less basis for attempting a ranking by quantity and quality factors combined, yet that is what is needed to rate the various seed sources.

The most logical method of combining quantity and quality factors seems to be this: (1) select those classes of trees which are considered satisfactory from the standpoint of vigor, form, and soundness; and (2) determine the volume of these trees for each source. The volume of desirable trees gives a combined measure of quantity and quality for each seed source.

Satisfactory trees in this instance were taken as those which had combined these characteristics: (1) good position in the stand, i.e., dominants or codominants competing with trees of equal or poorer development, (2) complete soundness, and (3) good form as evidenced by straight boles and uniform well-developed crowns.

About one sixth of the pines planted in 1931 were considered satisfactory trees. The volume per acre of satisfactory trees ranged from 0 to 56 cubic feet per acre (average 22) as compared with 27 to 270 cubic feet per acre (average 116) for all trees. The five best lots (upper 25 per cent) were all of central European type (94, 69B, 69A, 100, and 58), although those of northern European type ranked higher than they did on the basis of quantity criteria alone.

The pines planted in 1932 were only about 10 per cent satisfactory trees, and volumes of satisfactory trees were very low, ranging from 0 to 11 cubic feet per acre (average 2) as compared with 8 to 55 cubic feet per acre (average 20) for all trees. The best lot (109) was of central

European type. Except for it, there was little difference between the lots of central European and northern European type.

COMPARISON WITH RESULTS IN MINNESOTA

In the spring of 1931 Scotch pines of the same seed sources and nursery sowing were planted on the Superior National Forest in northeastern Minnesota. Except in local climate, this site differed from that in lower Michigan mainly in soil. The Minnesota plantation is on a silt loam; that in Michigan is on a fine sand.

At the same age (17 years from seed) the pines planted in Minnesota had much better diameter and volume, and a little better survival and height. The trees planted in Michigan had better form, a larger proportion of them were satisfactory, and such trees had a greater cubic-foot volume per acre. In quantity and quality combined, therefore, the Michigan plantation was superior.

PRACTICAL APPLICATION

Results at the end of 13 or 14 growing seasons (or after 15 to 17 years from seed) cannot give complete answers in a study of this kind. Final results must await the development of the trees to maturity. In this case further development is impossible because the plantations have been destroyed by fire. The present results, however, may give some basis for future seed collection or procurement policies.

Scotch pine is not apt to be grown for wood production in Lower Michigan, since the native jack pine (or red pine on the better sites) grows better and is less subject to disease and insect injuries. Because of its relative vigor and drought hardiness, however, Scotch pine probably will be planted for special purposes, particularly stream-bank or wind-erosion control on sandy areas, and for Christmas trees. With these restrictions in mind it seems reasonably safe to draw these conclusions at the end of 13 or 14 growing seasons in regard to planting Scotch pine on the Huron National Forest on Grayling fine sand:

1. For erosion-control, for which rapid growth is desirable and form is of secondary importance, Scotch pine of central European type promises best results. Seed from thrifty Lake States plantations seems best. Of the authentic foreign sources, seed from Austria gave best results.

2. When reasonably good growth combined with quality production is desired, two lots of the Riga variety (127 and 130) proved best. One

lot came from what used to be called the Province of Courland, in Latvia; the other was labeled only "Riga variety."

3. For Christmas trees, which should not grow too rapidly, a locally collected lot of apparent alpine origin (253) seems promising. These trees have a compact growth, and a bluish cast to the foliage almost as marked as that of blue spruce. Trees of this type are reported native in the higher mountain localities of Tyrol and parts of France.

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GROWTH STUDIES IN THE BEAL PINETUM, EAST LANSING, MICHIGAN

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THE growth of the Beal Pinetum on the Michigan State College campus has been watched with interest because it is the oldest plantation of white pine in Michigan. It occupies a three-acre area on the south bank of the Red Cedar River and is bounded on the west by Hagadorn Road. This plantation was established in 1896 by Dr. James Beal, for the purpose of covering up an unsightly abandoned gravel pit. Dr. Beal hoped to be able to show in later years that white pine could be grown as a crop on farm land not suitable for field crops. This area had been in corn before the gravel was dug, but the yields were very poor.

Forest tree seedlings were relatively expensive in 1896. Dr. Beal purchased five-year-old white pine for $20 per thousand. They were planted on a spacing of eight by twelve feet, which required 453 trees per acre. The per acre cost of establishment was reported by Chittenden (1922) as follows:

Planting stock	$ 9.06
Preparation of ground ...	10.00
Planting	10.00
Cultivation	5.00
Total cost per acre	$34.06

This tabulation does not include an estimated value of $15 per acre for the land, which is tax-free. The appearance of the pinetum five years after its establishment can be seen in Plate I, Figure 1.

Chittenden (1922) reported on the first twenty-five years of growth of the pinetum. In 1921 the tops of the trees had closed so that the crown canopy was fairly complete. No thinning had been done, but the lower branches of all the trees had been pruned to a height of fifteen feet, at a cost of $13 per acre. Chittenden recommended that the stand be thinned, but this was not attempted until 1926. He reported (1926) that in this operation only the inferior trees were removed, so as to give the remain-

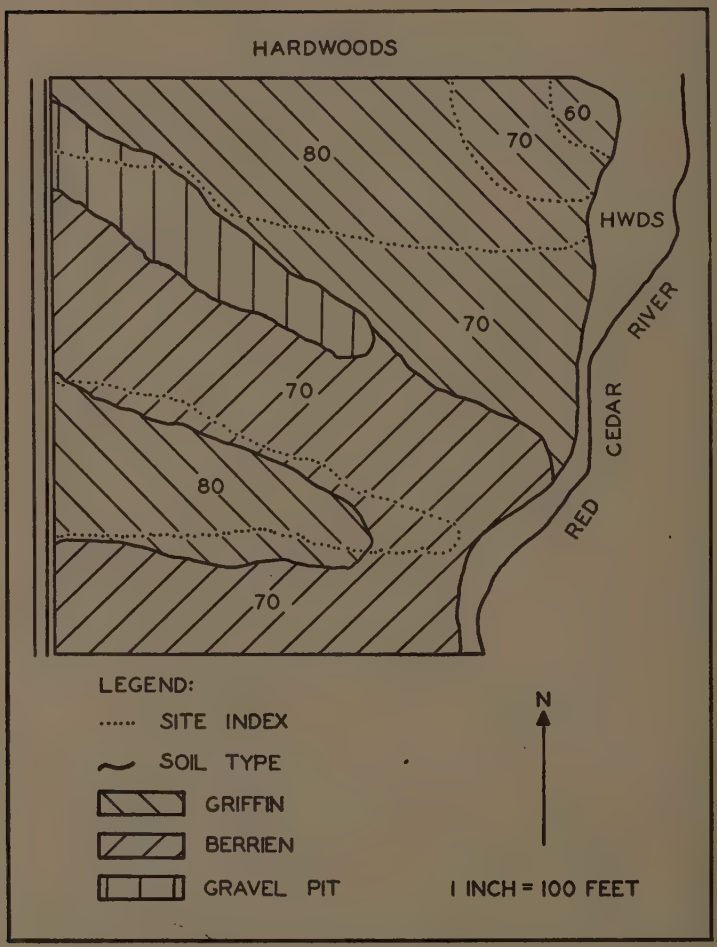

FIG. 1. Soil type and site index map of the pinetum. Site index is taken as total height at age fifty years

ing trees more light and room for growth. About 128 trees per acre were removed, which yielded nine long cords per acre (approximately 900 cubic feet of solid wood). This constituted one fifth of the volume of the stand. It was found that the sale value of the products derived from the operation just offset the labor charges.

The effect of this thinning can be seen on the face of recently cut stumps (see Pl. II). Acceleration of growth in diameter was evident the following year, and continued for the next five years, after which time the rate of growth seems to have been the same as before the thinning was made. No major thinnings have been made since 1926, but from time to time trees have been removed and utilized as they showed loss of vigor. At the present time there are 168 trees per acre. They average twelve inches in diameter (breast high), and the volume is about 15,600 feet board measure (International $\frac{1}{4}$-inch rule) per acre. The range in diameter is from five to eighteen inches and in total height from fifty to eighty feet. The total basal area is about forty-eight per cent of normal as given in the normal-yield table for white pine (Gevorkiantz and Zon, 1930). The pinetum as it appears today (1948) is shown in Plate I, Figure 2.

In 1947 a site-index study was made in the pinetum in an attempt to draw a correlation between the soil types and the site index of the stand and to account, if possible, for the difference in height growth throughout the stand. It was found that the site index (taken as the total height at age fifty years) was quite uniformly seventy feet on the Berrien soil, regardless of the depth of the surface layer or A-horizon. Even where all the surface layer had been removed from the gravel pit as overburden, the site index was still seventy feet. The site index for the Griffin soil was consistently higher than that for the Berrien. However, where the surface layer was less than six inches in depth, the site index was seventy feet for the Griffin also. Where the A-horizon was between six and ten inches deep on the Griffin, the site index was eighty feet. A-horizons deeper than ten inches were found near the river, but the trees averaged only sixty feet in height, owing possibly to the retarding effect on growth of periodic spring floods and the relatively poor subsoil drainage. The accompanying soil type-site index map (Fig. 1) was made by determining the average site index of six trees for each of a series of tenth-acre circular plots which were spaced sixty-six feet distant on lines run north and south with one hundred feet between them. Since the plantation was so nearly fifty years old, the site index could be assumed to be the present

total height. The soil type and the average depth of the A-horizon were determined for each plot.

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LITERATURE CITED

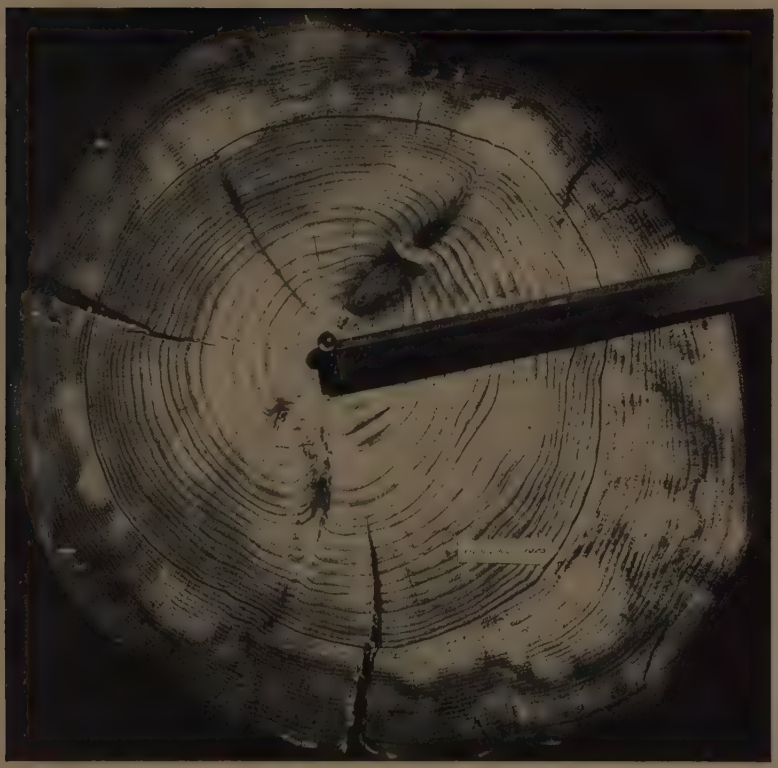
Chittenden, A. K. 1922. The Station's White Pine Plantation. Michigan Agricultural College Experiment Station, The Quarterly Bulletin, 4(3) : 105–106.

—— 1926. Thinning a White Pine Plantation. *Ibid.,* 8(3) : 142–145.

Gevorkiantz, S. R., and Zon, R. 1930. Second Growth White Pine in Wisconsin. Agric. Exper. Station, Research Bulletin 98.

FIG. 1. The Beal Pinetum five years after it was planted

FIG. 2. The Pinetum at present, fifty years after its establishment. The Beal monument is in the foreground



Cross section of a sixteen-inch stump. The black line indicates the 1925 thinning. Note the acceleration of diameter growth for the six years after the thinning

A STUDY OF PRIVATE UNPLATTED LANDS, FORMERLY STATE-OWNED, IN CHEBOYGAN COUNTY, MICHIGAN

EDWARD E. STURGEON

THE Michigan State Department of Conservation is charged with the administration of state lands lying in the counties of Oceana, Newaygo, Mecosta, Isabella, Midland, and Arenac, and those to the north. The officials of this agency want a check on the results of the current policy of selling state lands to individuals under the provisions of Section 131, Act 206, P. A. 1893. During 1947 surveys were conducted in Cheboygan and Emmet counties to experiment with methods for securing appropriate information.

In Cheboygan County 416 parcels of land comprising 20,648 acres were surveyed to determine present use.[1] These lands were purchased from the state by 314 owners in an eleven-year period beginning January 1, 1936. They had been in state ownership by virtue of their reversion through tax delinquency. Cheboygan County has 464,000 acres of land area, of which the state owned 116,500 acres, or 25 per cent, in 1945. The lands included in this survey make up 6 per cent of the privately owned area.

The Lands Division of the Department of Conservation carefully classifies all state lands deemed suitable for sale to individuals. A person applying for the purchase of this land is required to designate the use he intends to make of it. If his intentions are approved, the property will be placed on sale at the next state land auction. The applicant may bid at that time for the purchase of the property in competition with other

[1] The study was made under the supervision of Professor W. F. Ramsdell, School of Forestry and Conservation, University of Michigan. Mr. Fred Struhsaker, director of the Lands Division, Department of Conservation, and Mr. Charles Millar and Mr. Harry Galloway, also of the Lands Division, were instrumental in outlining the project. Financial aid for travel was provided from the Michigan Rural Rehabilitation Corporation funds under the supervision of Mr. Roswell Carr, state director of the Farmers' Home Administration.

interested persons. The importance of proper land use is pointed out to the buyer. Such precautions help to promote a more stable ownership pattern on those lands subject to periodic tax delinquency and subsequent reversion to state ownership.

This paper reports the preliminary results of the land-use study made of ownerships sold by the State of Michigan to individuals in Cheboygan County.

OFFICE PROCEDURE

The legal descriptions were listed from the records of the Lands Division early in 1947. All properties of twenty acres and over were included in the study if they had been sold since January 1, 1936. For each description the following information was copied from the abstract books: the name of the purchaser, the acreage, the date of the state deed, and the purchase price. From the tax rolls of Cheboygan County the assessed valuation and the taxes for the years 1937 and 1945 were recorded, and the 1945 taxes delinquent for one year were noted.

FIELD PROCEDURE

Each parcel of land listed for investigation was located in the field with the aid of the cover-type maps made by the Michigan Land Economic Survey (no longer in existence) in 1932. Where no boundary markers were visible, properties were found by checking cover types. All roads and trails bordering or crossing an ownership were traversed in order to examine the area. If the owner or tenant could be interviewed, he was questioned about the present use of his property. If not, often neighboring farmers, township officials, or realtors furnished valuable information.

PRELIMINARY RESULTS

Of the lands included in this survey, 10 per cent were purchased prior to January 1, 1941; 90 per cent were bought after this date. The peak year of acquisition was 1943, when 23 per cent were deeded to private owners. Increased buying in the latter half of the eleven-year period is attributed to the general prosperity of the war years, during which the more desirable properties available for purchase were sold by the state. The present policy of the Department of Conservation is, however, to retain possession of lands with access to water.

CLASSIFICATION OF LANDS BY USE

Table I classifies the total acreage surveyed according to eleven kinds of land use evident in Cheboygan County in 1947. The factor of multiple use makes this classification somewhat discretionary.

TABLE I

CLASSIFICATION BY USE OF LANDS STUDIED

Use	*Acres*	*Percentage*
Pasture	4,523	21.9
Timber	3,047	14.8
Speculation	3,016	14.6
Idle	2,835	13.7
Hunting	2,179	10.6
Woodlot	2,133	10.3
Unknown use	1,001	4.9
Crops	647	3.1
Orchard	456	2.2
Rural residence	455	2.2
Summer residence	356	1.7
Total	20,648	100.0

Pasture. — Almost 22 per cent of the total area serves as pasture. All such lands are fenced, and about 65 per cent are cleared. Farmers have found a dependable income in selling cream to local buyers. The present demand for pasture makes this use of first importance according to area.

Timber. — Lands used for growing timber include those from which wood and wood products are sold by the owner. Pulpwood, sawlogs, Christmas trees, cedar boughs, cabin logs, and firewood are among the items produced. Very few areas have merchantable timber of sawlog size.

Speculation. — The ownerships purchased for speculative interest include 3,016 acres, or 14.6 per cent of the total acreage. Few owners acknowledged buying land from the state with the intention of selling it later at a profit. In some instances neighbors or realtors divulged the speculative plans of certain parties. Lands which were for sale after the owner had removed marketable timber were placed in this category, although only a few were observed. The fact that some properties had been resold once or twice indicated speculative interests.

Realtors and merchants are among the speculators. An injustice is done the farmer at the land auction when he is outbid by these interests

on a piece of land that would make a profitable addition to his farm. Speculation is an evil where it seriously inflates land prices and fosters improper use.

The one outstanding example of this activity in the county is the operations of a Detroit realty company. Since 1941 it has purchased 35 legal descriptions in Cheboygan County totaling 1,370 acres. The name of the firm is designed to lead people to believe they are dealing with a state agency. It usually buys at the minimum price the lands not bid on at the auction. Several township assessors report difficulty in determining whether or not certain parcels of land have been sold by the firm and, if so, what are the names and addresses of the present owners. This situation has resulted in tax delinquency on a few parcels of land. Two transactions were reported in which the firm realized 600 per cent profit. The Department of Conservation is not empowered to control the sale of state land so as to prevent its falling into this type of use. The deed restriction has been considered an effective way of combating speculation.

Idle land. — The "idle" classification includes 2,835 acres of land which were not in any use and for which the owner had no immediate plans. He either was undecided about what he should do with the land or was reluctant to divulge his intentions. In some instances it was obviously purchased as an investment pending a decision in regard to its future use.

Hunting. — Ten per cent of the lands surveyed are used for hunting. This activity is increasing in importance as a new basic use. Hunters usually build a cabin on their property and make it a center for hunting activities. In general, hunting lands are of low quality and support only brush or poor to fair immature timber.

Woodlots. — Woodlots are defined as lands from which the owner takes wood for his own consumption. Of the 2,132 acres in this use about 35 per cent are pastured. Although this combination use is an improper practice from the standpoint of forestry, the demand for pasture makes it rather extensive.

Unknown use. — Lands were placed in the "unknown" class if their use could not be determined from observation or if the owners were not available for questioning. A small percentage of them may be nonresidents of the county.

Crops. — About 3 per cent, or 657 acres, of the total land in this class is used as cropland. Cultivation is attempted only on the better clay soils.

Orchards. — Late frosts have discouraged most orchardists in the county. Of the 456 acres in this class a Detroit company owns 320. It has erected a fruit-processing plant for making juice.

Rural residence. — A rural residence is interpreted as a property on which the occupant lives all year, but from which he does not make his living. There are 455 acres of such land. Several rural homes have been built near small trading centers.

Summer residence. — Plots on which twelve summer residences have been built total 356 acres. The houses are usually near lakes, streams, or small trading centers, but the sites of several have been chosen to take advantage of scenic views.

DEDUCTIONS FROM TAX ROLL STATISTICS

Table II presents tax information on the lands considered. Unassessed lands, which comprise 32 per cent of the total area, were listed on the county tax records as state lands, although they had previously been sold by the state. This discrepancy is explained by the lapse in time between the sale of the property and the recording of the new owner's name on the tax rolls. The township assessor is often the person responsible in this irregularity. Such inefficiency results in the loss of tax revenues to the local units. In lieu of taxes the state pays the county at the rate of 10 cents per acre for state-owned land. The average tax levied

TABLE II

TAX ROLL STATISTICS FOR LANDS STUDIED
(Figures in parentheses are averages for one acre.)

Tax classification	Acres	No. of owners	No. of parcels	Purchase price	Taxes	Assessed valuation
Unassessed, 1945	6,706	98	...	$24,174 (3.60)	...	...
Assessed, 1945	13,942	216	...	36,619 (2.62)	$908.58 (0.065)	$61,649 (4.42)
Delinquent, 1945	4,061	78	...	12,242 (3.00)	347.47 (0.085)	22,425 (5.52)
Comparable 1937 ...	8,378	...	...	...	732.30 (0.087)	50,511 (6.00)
Comparable 1945 ...	8,378	143	162	...	642.67 (0.077)	43,375 (5.20)
All lands studied	20,648	314	...	60,403 (2.92)	...	...

in 1945 by Cheboygan County on private lands included in this study amounts to 6.5 cents per acre. Therefore the local unit derives more revenue from land in state ownership.

The properties included in the delinquent group are those for which the 1945 taxes were not paid. Almost 30 per cent of the lands assessed bear delinquent taxes for at least one year, and such taxes make up 38 per cent of the total assessed taxes.

Lands with comparable tax data for the years 1937 and 1945 are those for which the assessed valuation and taxes were listed in the county records. Although there was a substantial decrease in taxes after the passage of the 15-mill limitation in 1932, a further 14 per cent reduction of taxes and a 16 per cent drop in assessed valuation occurred between 1937 and 1945. Since 1937 increased grants-in-aid from the state have made lower taxes possible. The average assessed valuation per acre of lands on the 1937 tax roll was $6.05, whereas that for 1945 was $5.18. The average ownership of 64 acres was purchased from the state for $2.62 per acre.

CONCLUSION

Although insufficient time has elapsed since the sale of these state lands to make a conclusive statement on the policy of the Department of Conservation, distinct partial success is evident at present. A conservative estimate at this time indicates that at least 50 per cent of the properties are dedicated to uses that will effect a stable ownership pattern. Some specific indications of probable future reversion can be detected. The land policy will be most effectively tested in the next depression.

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THE RENNERFELT METHOD FOR DETERMINING THE OCCURRENCE OF DECAY AND ITS APPLICATION TO MICHIGAN FORESTS

REED W. VARNER

ULTIMATE cull in timber caused by defects that develop during the life of a forest is a significant factor in the preparation of a sound management plan. No estimate of future losses based upon study of existing immature stands has been made in Michigan.

Accurate prediction of the amount of defect that will appear in young present-day stands calls for an inventory of the number of trees already attacked by fungi as well as a knowledge of the identity and growth characteristics of the organisms involved. Numerous investigators (1, 2, 3, 5) have attempted to estimate the extent of fungus activity in a forest through observation of such factors as the frequency, position, and species of fruiting bodies on the trees. However, on certain sites and with some tree species, external evidences of deterioration are lacking even in forests where cull is great. In jack pine (*Pinus Banksiana* Lambert), for example, fruiting bodies cannot be used to determine the amount of rot present as conks of wood-destroying fungi are exceedingly rare in green standing individuals of this species.

Since exterior indications of defect are often unreliable or even lacking, basic information required for cull prediction in young stands can be obtained only by the employment of cultural techniques. With the methods commonly used in the past, however, extensive investigations of this nature could not be carried out at reasonable cost except in connection with commercial cutting operations. Therefore, rot-incidence data were not easily gathered for tree sizes below the merchantable diameter limit for the species involved.

Rennerfelt (4), working in Sweden, obtained pure cultures of wood-rotting fungi from living trees by the use of Swedish increment borer cores removed under aseptic conditions. His work seemed to provide a basis upon which a technique might be developed for making inventories of

incipient decay in young forests easily and without seriously damaging the trees. Accordingly, a procedure for obtaining isolations in the forest was devised and tested in stands of jack pine in the central part of the Lower Peninsula of Michigan.

FIELD PROCEDURE

Sterile petri dishes half-filled with malt extract agar were used as incubation containers. Each dish was wrapped individually in waxed paper, held in place by a rubber band, to reduce contamination during transportation and handling.

Other equipment included a six-inch Swedish increment borer, a pocketknife, a piece of cloth, and two bottles of 1 : 1000 solution of mercuric chloride. One of these containers was tall enough to permit the bit and the extractor of the increment borer to be completely immersed in the corrosive sublimate. These items and a quantity of the wrapped plates were easily carried in a paper carton of moderate size.

At the point where the core was to be taken from the tree, the bark over an area of about one square inch was removed, and the freshly exposed surface was moistened with mercuric chloride. The bit of the increment borer, after having been covered by the disinfectant for at least a minute, was shaken free of excess moisture, placed in the handle, and turned into the tree within the prepared area. Care was taken to prevent either end of the bit from being brought into contact with contaminated surfaces. The sterile extractor was permitted to drain for a few seconds prior to the withdrawal of the section, since too great a residue of mercuric chloride caused the wood to become soaked and prevented all fungus growth. The specimen was placed in a petri dish immediately if it was short enough to rest flatly upon the agar surface. Longer cores were cut into pieces with a sterile knife while still on the extractor. The dish was then again wrapped in waxed paper.

This method was first tested in the field during an exceedingly dry period and on a day with frequent gusts of wind up to approximately fifteen miles per hour. Under these difficult conditions about 30 per cent of the plates became contaminated. It was possible, however, to save all except 5 per cent of the cores by prompt transfer from plates in which contaminants appeared.

As mercuric chloride causes rapid corrosion of certain metals, the increment borer and the knife used in this work were washed with water and dried at the end of each period of use in the field.

APPLICATION OF THE RENNERFELT METHOD IN TWO JACK-PINE STANDS

The Rennerfelt method was applied in two jack-pine stands near East Tawas, Michigan, on the Lower Michigan National Forest.

The first of these, designated Area A, was determined on the basis of site-quality tables presented by Wackerman, Zon, and Wilson (6) to be of "medium" quality for jack pine. The average age of the trees was thirty years. Diameters at breast height ranged from 4.1 to 8.9 inches, with an average of 6.5 inches. Slightly over half of the trees exhibited areas of charred bark near the base which were found to cover fire scars caused five years previously. The stand contained about 800 stems per acre, and this stocking was sufficient to result in the death of all branches below the midpoint in the height of the tree. There were few branches of more than 1.5 inches in diameter at their base. No external evidences of fungus activity existed.

The site quality for jack pine of Area B was classified as "poor." Here the age of the trees was approximately fifty years. The diameters ranged from 4.8 to 8.3 inches, with an average of 6.4 inches. The stand density was a little less than 600 trees per acre. As a consequence of satisfactory natural pruning, the proportion of branches with a diameter of more than 1.5 inches was small. Almost 50 per cent of the individuals examined on this area had fire scars, all of which were twenty-three years old and many of which had completely healed. Rot was not evident at any of the wounds, and there were no other indications of defect.

All of the trees were sampled on a random strip one tenth of a chain wide through the center of each area. To obtain information on the incidence of both butt-rotting fungi and those that cause stem rots, one core was taken from the tree at a point six inches above the ground and another at a height of five feet. All borings extended well beyond the center of the tree, and the cores were placed in petri dishes with identifying numbers. The accompanying field notes included a record of the diameter, a description of wounds, and expressions of branch size for each tree bored.

The petri dishes containing the cores were incubated at room temperature for a period of forty days in the laboratory. Fungus growth developed on some of the samples within seven days (Pl. I, Fig. 1). For most of the cores, however, mycelium developed only after a period of two to three weeks. No new growth appeared after four weeks. All the fungi isolated were determined as *Fomes Pini* (Thore) Lloyd.

Ten per cent of the trees on Area A were shown to be infected with

the fungus, whereas 40 per cent of those on Area B had been attacked. On each area the percentage of jack pine infected with *Fomes Pini* was the same for trees with visible wounds as for those without.

The accuracy of the results obtained by the Rennerfelt method was checked by actually felling the trees sampled. It was found that a similar red stain was exhibited by all individuals from which cores yielding *Fomes Pini* had been obtained (Pl. I, Fig. 2).

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LITERATURE CITED

1. BAXTER, DOW V. 1941. Pathology in Forest Practice, 618 pp. John Wiley & Sons, Inc., New York.
2. BOYCE, J. S. 1930. Decay in Pacific Northwest Conifers. Yale Univ., Osborne Bot. Lab., Bull. 1 : 1–51.
3. HORTON, GERALD S., AND HENDEE, CLARE. 1934. A Study of Rot in Aspen on the Chippewa National Forest. Journ. For., 32 : 493–494.
4. RENNERFELT, ERIK. 1945. Om granens rotröta, dess förkomst och utbredning. Svenska Skogsvårdsför. Tidskrift, 43 : 316–334.
5. SPAULDING, PERLEY, HEPTING, G. H., AND WESTVELD, M. 1934. Revised Suggestions for Estimating Cull in Northern Hardwoods. U. S. Dept. Agric., Northeastern Forest Exper. Sta. Tech. Note No. 14 : 1–3.
6. WACKERMAN, A. E., ZON, RAPHAEL, AND WILSON, F. G. 1929. Yield of Jack Pine in the Lake States. Univ. of Wis., College of Agric., Research Bull. 90 : 1–23.

FIG. 1

FIG. 2

FIG. 1. *Fomes Pini* mycelium on an increment borer core taken from a living jack-pine tree which exhibited no external evidences of defect

FIG. 2. A section of a fifty-year-old jack pine from Area B. This tree, before felling, was shown by the Rennerfelt method to be infected with *Fomes Pini*. The dark area at the center of the piece is red rot caused by the fungus.